AD-A062 006   DAYTON UNIV OHIO RESEARCH INST   F/G 5/5
PHOTOMETRIC METHODS FOR THE ANALYSIS OF HUMAN KINEMATIC RESPONS--ETC(U)
OCT 78   P A GRAF, H T MOHLMAN, R C REBOULET   F33615-73-C-4157

UNCLASSIFIED   UDRI-TR-76-88   AMRL-TR-78-94   NL

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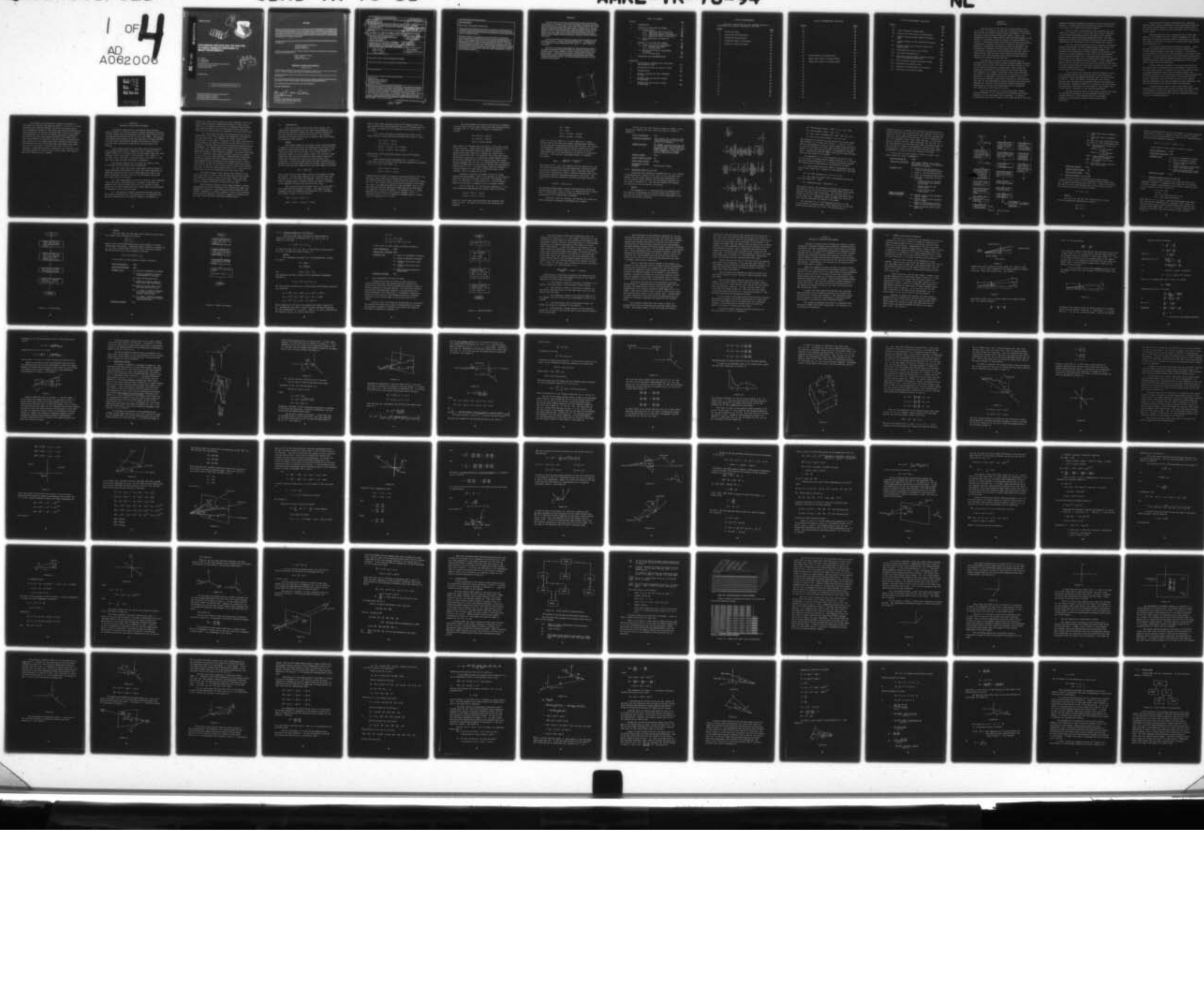

AMRL-TR-78-94

PHOTOMETRIC METHODS FOR THE ANALYSIS OF HUMAN KINEMATIC RESPONSES TO IMPACT ENVIRONMENTS

P. A. GRAF
H. T. MOHLMAN
R. C. REBOULET
UNIVERSITY OF DAYTON RESEARCH INSTITUTE
300 COLLEGE PARK AVENUE
DAYTON, OHIO 45469

OCTOBER 1978

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AEROSPACE MEDICAL RESEARCH LABORATORY
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

NOTICES

TECHNICAL REVIEW AND APPROVAL

AMRL-TR-78-94

The experiments reported herein were conducted according to the "Guide for the Care and Use of Laboratory Animals," Institute of Laboratory Animal Resources, National Research Council.

The voluntary informed consent of the subjects used in this research was obtained as required by Air Force Regulation 80-33.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

Henning E. von Gierke

HENNING E. VON GIERKE
Director
Biodynamics and Bioengineering Division
Aerospace Medical Research Laboratory

AIR FORCE/56780/28 November 1978 — 100

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

9 REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER
18 AMRL-TR-78-94

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER
9

4. TITLE (and Subtitle)
6 PHOTOMETRIC METHODS FOR THE ANALYSIS OF HUMAN KINEMATIC RESPONSES TO IMPACT ENVIRONMENTS.

5. TYPE OF REPORT & PERIOD COVERED
FINAL REPORT.
25 Jun 1973 - 30 Nov 1976
9

6. PERFORMING ORG. REPORT NUMBER
UDRI-TR-76-88
2

7. AUTHOR(s)
10 P.A. Graf, H.T. Mohlman, and R.C. Reboulet

8. CONTRACT OR GRANT NUMBER(s)
14
15 F33615-73-C-4157

9. PERFORMING ORGANIZATION NAME AND ADDRESS
University of Dayton Research Institute
300 College Park Avenue
Dayton, Ohio 45469

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
17
62202F, 7231-06-39,
16

11. CONTROLLING OFFICE NAME AND ADDRESS
Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio 45433

12. REPORT DATE
11 Oct[redacted] 1978

13. NUMBER OF PAGES
248

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)
12 248p.

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Impact Tests
Photometric Data Reduction
Biodynamic Data Analysis
Computer Program

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the processes, procedures, and techniques developed to evaluate the biodynamic response of body segments to laboratory simulations of aircraft crash and escape system environments. These simulations were conducted on the test facilities, principally the Vertical Drop Tower, the Horizontal Impulse Accelerator, and the Square Wave Impact System, located at the Aerospace Medical Research Laboratory, Impact Branch (presently known as Biomechanical Protection Branch), Wright-Patterson Air Force

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

105 400

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Base, Ohio, by personnel of that Branch.

The processes described were developed to determine the time histories of coordinate locations of anthropometric points during the impact and immediately post impact phases during which the anthropometric points demonstrated planar or nonplanar motion.

Coordinate systems were defined for each of the various test facilities. Reference points were marked with fiducials and their coordinates were surveyed. Body segments of the subjects were defined by fiducials affixed to anthropometric points which were measured prior to each test. The tracks of these points were recorded on high speed (500 fps) 16mm motion picture cameras throughout each test event. The film frame coordinates of the points were digitized and electronically processed to define the time-seat coordinate position history of the motion for linear and angular displacement, velocity, and acceleration analysis.

PREFACE

The data reduction processes described herein were developed and implemented for the benefit of the Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, under Contract F33615-73-C-4157, which was partially funded by the Department of Transportation, National Highway Traffic Safety Administration, under Interagency Agreement DOT-HS-017-1-017-IA. This contract was monitored initially by Capt John T. Shaffer and later by Maj John P. Kilian of the Impact Branch (presently known as Biomechanical Protection Branch), Aerospace Medical Research Laboratory.

University of Dayton personnel who made major contributions to the program include W. J. Hovey, Project Supervisor, H. T. Mohlman and R. C. Reboulet, Research Mathematicians, and P. A. Graf, Research Technician.

The authors gratefully acknowledge the cooperation and assistance provided by personnel of the United States Air Force; particularly Mr. J. Brinkley, Maj J. Kilian, SMSgt J. Powers, and all the personnel of the Impact Branch. Cooperation and assistance of personnel of Technical Photographic Division, 4950th Test Wing, and personnel of the Digital Computer Operations Division, Aeronautical Systems Division, are also gratefully acknowledged.

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SECTION I

INTRODUCTION

Accelerations of less than one second duration occur in a variety of aerospace environments including escape system and aircraft and surface vehicle crash environments. The 6570th Aerospace Medical Research Laboratory (AMRL), Bionics and Biodynamics Division, Impact Branch (BBI) has been engaged in the conduct of experimental tests to assess the effectiveness of a variety of restraint systems and protective devices by evaluating biomechanical responses of manikins, primates, and humans to exposure to laboratory simulations of these environments. The biomechanical responses to such exposure were evaluated from strategically located and oriented monitoring devices, such as accelerometers and load cells whose outputs were recorded on magnetic tape, and high-speed motion picture cameras mounted offboard and onboard the test vehicles.

The reduction of electronically recorded data was accomplished in routine fashion using accepted methods to derive the Gadd Severity Index (SI) and/or Head Injury Criterion (HIC) from triaxial acceleration time-histories. While these are recognized indicators of the probability of injury resulting from exposure to an impact environment, they do not describe the motion of body segments other than at the point, or points monitored. To adequately describe the responsive motion of the many body segments, quantitative analysis of time displacement data of the anthropometric points defining the various body segments was required. The photometric system designed and implemented to satisfy this requirement was an integrated data acquisition, data reduction system.

Data were recorded on at least three 16mm cameras mounted offboard, or in a combination of offboard and onboard, depending on the environment being simulated. If vehicle accelerations were not to exceed a peak acceleration of 20g, two

cameras were mounted onboard the vehicle with two others mounted offboard. If peak vehicle accelerations in excess of 20g were anticipated, all cameras were mounted offboard.

When the photo instrumentation plan specified that all cameras be offboard, one or two primary data cameras (depending on the vehicle displacement during the event), were mounted normal to the plane of principal predicted motion. Two other cameras were mounted such that their optical axes were mutually perpendicular to the optical axis of the primary data camera.

When the photo instrumentation plan required the onboard/offboard combination, the two onboard cameras were located and oriented with respect to a vehicle coordinate system. The locations and orientations of these cameras varied from one test program to another depending on the size of the test subjects, type of predicted motion, etc., with principal consideration being given to the fact that all tracked points had to be observed by both cameras throughout the entire event. Of the offboard cameras one was located with its optical axis normal to the plane of principal motion and the other was located such that its optical axis was aligned parallel, or as nearly parallel as practical, to the axis of vehicle motion.

Prior to each test, fiducials, one-inch diameter circles with alternating black and yellow quadrants, were applied in accordance with the recommended practice, SAE J138 (see Figures B1 and B3). After the subject was adjusted to the initial position, the locations of the applied fiducials were measured and recorded. Reference fiducials, installed on the test fixture and surveyed at initiation of a test series, were checked prior to each test to determine if any required replacement.

The data reduction phase of the system involved digitizing the film plane coordinates of the reference fiducials and tracking fiducials, time synchronizing of film frames, calculation of conversion factors, and electronic data processing.

The projected film frame coordinates were digitized, frame by frame, using a Producers' Service Corporation model PVR film analyzer interfaced to a type 35 teletype terminal (TTY). The TTY generated a listing and punched paper tape of formatted digital values.

The digitized data were transmitted from the TTY tape reader to the computer via voice quality telephone line. The data file was edited to correct format or characters as required then saved on disk file and copied to punched cards which served as the permanent file.

The system contained three processing programs. HIFPD was used to process planar motion of points as observed by a camera mounted normal to the plane of motion. This program was initially written to yield time histories of coordinate points relative to the test vehicle and of the test vehicle relative to the range. It was shortly thereafter modified to derive relative linear and angular velocities and accelerations of the points and to prepare plots of these data.

Program SLED was designed to take data digitized from two camera views, synchronize the data timewise, and solve for the most likely points of intercept of up to four pairs of rays in a three-dimensional rectilinear coordinate system. The successful operation of this program required precise determination of the coordinates of the focal point of each camera and the azimuth, elevation, and roll angles of each of the cameras. Physical measurements of these parameters proved inadequate, thus the third program in the system, POOCH, was developed.

Program POOCH is used to derive the location and orientation of a camera and a factor including the focal length of the camera lens and the magnification of the projector. It optimizes these parameters based upon the surveyed coordinates of up to 20 reference points.

The cameras were operated at a nominal film speed of 500 frames per second, with exposure time of 0.4 msec to 0.8 msec depending upon predicted maximum velocities of tracked points and illumination intensity. Film timing and camera synchronization were provided for by the use of pulsed LED's, driven by a common pulse generator at a rate of 100 pulses per second, recorded on one side of the film just beyond the edge of the image frame. Due to the location of the LED in the film path, any given pulse was recorded 11 to 13 frames behind the coincident image frame, depending on the size of the film slack loop between the supply reel and the film gate. To minimize the error due to this variance, a synchronizing pulse, recorded on the electronic data recording system, was used to fire a strobe light, the flash of which was observed by all cameras.

SECTION 2
ANALYSIS OF DATA FROM ONE CAMERA

Horizontal Impact Facility Photometric Data Analysis Program (HIFPD) is a digital computer program developed to analyze the Hyge Impact Facility Photometric data for Impact Branch of the Biodynamics and Bionics Division of the 6570th AMRL. The program was compiled and executed on the CDC computers at Wright-Patterson Air Force Base. The standard CALCOMP plot package is used to plot data and thus must be attached to load and execute the program.

This program inputs the code sheet data and program control parameters described in Appendix A and a maximum of 300 (MAXN) frames of X, Z position data for the range, sled, hip, knee, shoulder, elbow, head point 1 and head point 2 for ITYPE = 0 or range, sled, head point 1 and head point 2 for ITYPE = 1. The data card format are also described in Appendix A.

The program computes the following four types of data as requested by the program control parameters:

(a) The input data versus frame number and the frame to frame differences are printed in counts. The range difference is subtracted from the frame to frame differences for each of the seven parameters. The only value of this difference data would be to spot errors in the data.

(b) The displacements (X and Z) of the hip, knee, shoulder, elbow, head point 1 and head point 2 relative to the sled are computed, and a moving eleven point (NP = 11) quadratic least square fit is used to smooth the data. These data are also plotted, if requested on the test setup card.

(c) The angles in radians between the shoulder and hip and between the head point 1 and head point 2 are computed using the above smoothed data. The angular velocity is computed in

radians per second using a moving 11 point quadratic fit of the angle versus time data (computes derivative of least squares equation). The angular acceleration is computed using a moving eleven point quadratic fit of the velocity versus time data. These data are also plotted as requested on the test setup card.

(d) The linear velocity and acceleration data for any combination of the eight variables are computed as requested on the test setup card. For example, the linear velocity and acceleration of the head pt 1 relative to the range, sled relative to the range or the head pt 1 relative to the sled can all be computed. Note that range relative to some other parameter cannot be computed. To compute these linear velocity and acceleration data, the X and Z displacements are computed for the variable of interest relative to the reference variable. A moving eleven point (NP = 11) quadratic least square smoothing function is applied to both the X and Z time histories. The resultant displacement in feet is computed from this smoothed data. A moving eleven point quadratic fit is applied to this resultant data to obtain the velocity in feet per second and a second eleven point quadratic fit is applied to the velocity data to obtain the acceleration data in feet per second squared and in G's. These data are printed and plotted as requested on the test setup card.

The three external files used by this program are the input file (unit 5) used to read all code sheet and data cards, the output file (unit 6) used to print all output, and TAPE7 (unit 7) used to generate the plotter tape. A magnetic tape must be requested with TAPE7 as the local file name.

The following sections of this report present a general description of the main program and all subroutines except the CALCOMP plot routines. Flow charts are also included for each routine. Appendix C contains a complete listing of the program source deck and Appendix D contains a sample run complete with all input and output data (including CALCOMP plots).

2.1 PROGRAM HIFPD

This main routine controls all input, output, and computations requested by the test setup card parameters. All subroutines required to smooth the data, compute derivatives, and plot results are called by this routine. All program diagnostics resulting from errors in setup or data card formats are printed by this routine.

Method

The program reads the code sheet control cards described in Appendix A and initializes the program print and plot control parameters. The program reads the card code, frame number, and X and Z axis data for four (ITYPE = 1) or eight (ITYPE = 0) variables (index J) for each frame (index I) in the test. Frame number and card code are checked for input errors; errors in input cause diagnostics to be printed and the test to be terminated. If more than MAXN frames are read, diagnostics are printed and all frames beyond MAXN are omitted from the analysis. The T(I) time data are computed from the frame number as follows:

$$T(I) = IFR(I)/DT$$

where IFR(I) is the frame number and DT is the number of frames per second. If setup card parameter IRX is greater than zero, the sign of all X axis data are changed. After all data are read, a summary page is printed listing all types of analyses to be computed, printed, and plotted for this test.

When program control parameter IPR $\geq$ 0, all raw input X and Z axis data are printed in counts. The frame to frame difference data are computed and printed for all J variables from frames 1 equal 2 to N as follows:

$$XD(1) = X(I,1) - X(I-1, 1)$$

$$XD(J) = X(I,J) - X(I-1,J) - XD(1).$$

XD(1) is the range difference from the I^{th} frame and XD(J) is the variable minus range difference for the J^{th} variable and the I^{th} frame. The above are also computed and printed for the Z axis data.

All X and Z axis data are adjusted for shifts in the range reference reading and then converted from counts to feet:

$$H1 = X(I,1) - X(1,1)$$

$$H2 = Z(I,1) - Z(1,1)$$

$$X(I,J) = (X(I,J) - H1) * CAL(J)$$

$$Z(I,J) = (Z(I,J) - H2) * CAL(J)$$

where CAL(J) is the calibration factor for the J^{th} variable (J = 2 to 8).

When program control parameters IPC < 2 or IPA < 2, X and Z axis motion relative to the sled are computed for variables 3 to 8 (or 7 and 8 for ITYPE = 1):

$$XD(I) = X(I,J) - X(I,2)$$

$$ZD(I) = Z(I,J) - Z(I,2).$$

Subroutine SM is called to compute a moving eleven point (NP = 11) quadratic least square fit to smooth the X and Z axis data. The smoothed data are stored in arrays XX(I,JJ) and ZZ(I,JJ) where JJ = J-2. As a result of the eleven point smoothing, five frames are lost at the beginning and end of the test data; this is true each time the data are smoothed by subroutine SM or derivaties are computed by subroutine DERIV1. If parameter IPC < 2, these smoothed data relative to the sled are printed; if IPC < 1, subroutine CPLT is called to generate a CALCOMP plot of X versus Z for all variables (J = 3 to 8).

The angle between the shoulder and the hip is computed for each frame using the above smooth data when program control parameter IPA < 2. The angle in radians is computed as follows:

$$H1 = ZZ(I,3) - ZZ(I,1)$$

$$H2 = XX(I,3) - XX(I,1)$$

$$XD(I) = \arctan(H1/H2)$$

where index 3 is shoulder data and index 1 is hip data in the XX and ZZ arrays. Angles XD(I) are adjusted by factors of 2π to make them continuous. Subroutine DERIV1 is called to compute the angular velocity in radians per second from a moving eleven point (NP = 11) quadratic fit of the XD(I) data and angular acceleration in radians per second squared from an eleven point quadratic fit of the velocity data. The angular data are printed and, for IPA = 0, subroutine CPLT is called to generate CALCOMP plots of the angular velocity and acceleration versus time (IP = 2). All above angular data are computed in a similar manner for head point 1 minus head point 2 data (indices 5 and 6 in arrays XX and ZZ).

Parameter M contains the number of sets of linear velocity and acceleration data to be computed for one variable (array ID) relative to another (array IR). For example, if ID(1) = 3, and IR(1) = 2, then for set M = 1 the hip motion relative to the sled is computed for all available frames.

If M < 0 and IPL < 2, all data for variables J = 2 to 8 are adjusted by subtracting the initial value as follows:

$$X(I,J) = X(I,J) - X(1,J)$$

$$Z(I,J) = Z(I,J) - Z(1,J)$$

where all X and Z data have previously been converted from counts to feet. For each of the M sets the following are computed:

$$JD = ID(K)$$

$$JR = IR(K)$$

$$DI(I) = X(I,JD) - X(I,JR)$$

$$DC(I) = Z(I,JD) - Z(I,JR)$$

where K is the set index (K = 1 to M). When JR is 1 above, X(I,JR) and Z(I,JR) data are deleted, because motion relative to the range has already been removed from the data (see calibration equations). Subroutine SM is called to apply the eleven point quadratic smoothing function to the DI(I) and DC(I) displacement data; the smoothed data are stored in arrays XD(I) and ZD(I). The resultant displacement RES(I) is computed as follows:

$$RES(I) = \sqrt{XD(I)^2 = ZD(I)^2}.$$

The maximum XD(I), ZD(I) and resultant and the minimum XD(I) and ZD(I) are also determined from the above data. Subroutine DERIV1 is called to compute the velocity, VEL(I), from the resultant data and the acceleration, ACC(I), from the resultant data using eleven point quadratic smoothing functions in each case. The acceleration data are converted from feet per second squared to G's:

$$ACCG(I) = ACC(I)/32.2.$$

All the above displacement, velocity and acceleration data are printed versus time. Also, if IPL = 0, subroutine CPLT is called (IP - 3) to plot the velocity in feet per second and the acceleration in G's versus time in seconds.

After all tests are analyzed, the CALCOMP plot subroutine PLOTE is called to terminate the CALCOMP plot routines.

A flow chart for this routine is shown in Figure 1 and a sample test complete with all input and output is listed in Appendix D.

Error Diagnostics:	YES
Subroutines Required:	CPLT, DERIV1, SM, PLOTS, and PLOTE (PLOTS and PLOTE are part of the CALCOMP plot package.)
COMMON Required:	The COMMON variables actually used to transfer data are described in subroutine CPLT. Many of the blank COMMON variables in this routine are in COMMON only to reduce required compilation storage.
Program Length:	5342_8
Labeled Common Length:	23_8
Blank Common Length:	12616_8
CM Required to Load Program:	Approximately 50000_8

2.1.1 Subroutine CPLT (T,Y, Z, IP)

Subroutine CPLT generates a CALCOMP plot of: (a) X versus Z displacement with respect to the sled for all available parameters, (b) time versus angular velocity and acceleration, or (c) time versus linear velocity and acceleration depending on the value of parameter IP. The standard CALCOMP plot package is required to load and execute the program.

Method

For parameter IP = 1, CPLT generates one composite plot of X versus Z displacement for variable motion with respect to the sled. All X and Z scaling are set by CPLT independent of the data and are defined as follows.

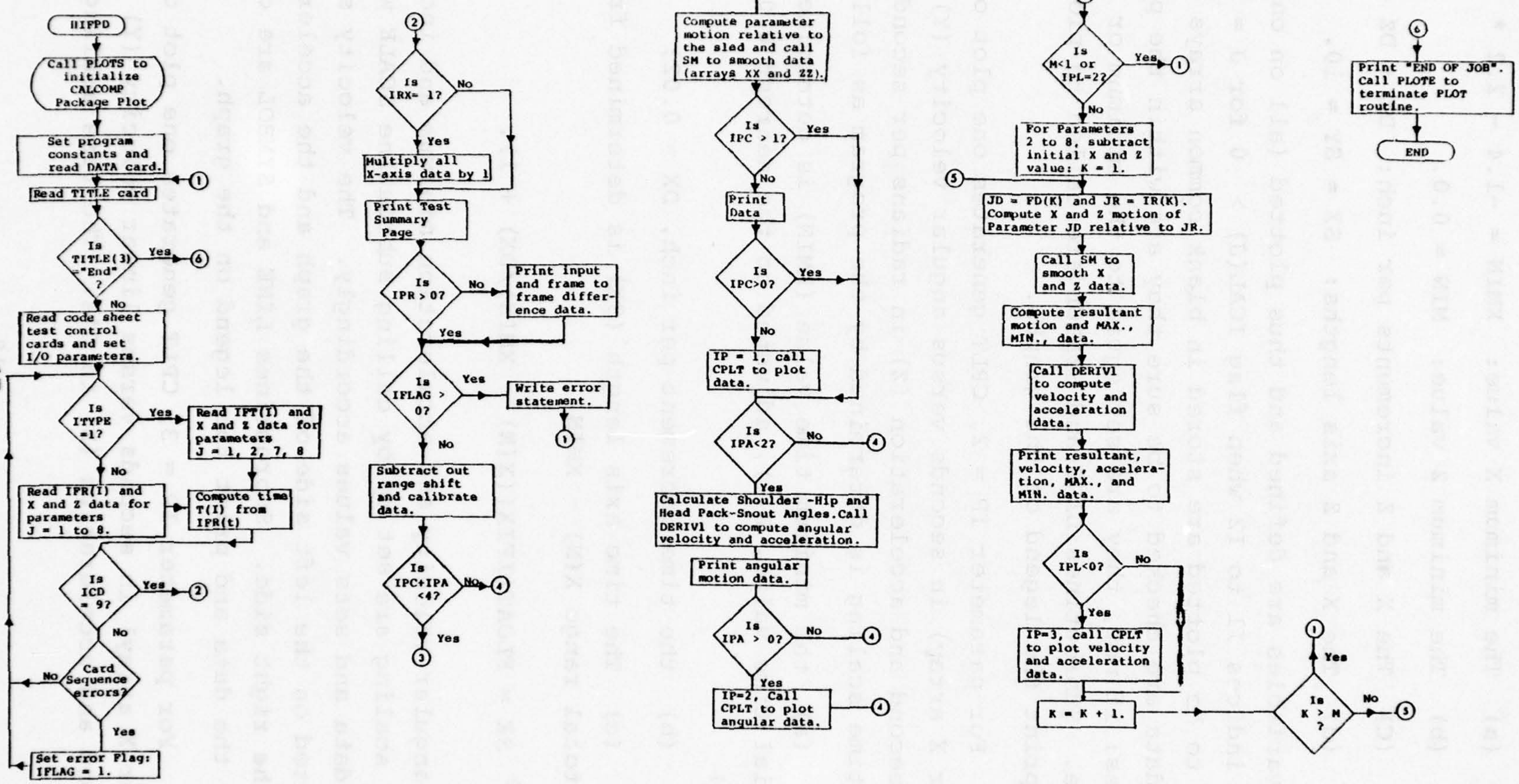


Figure 1. HIFPD Flow Chart.

(a) The minimum X value: XMIN = -1.4 - 2.2 * IRX.

(b) The minimum Z value: MIN = 0.0.

(C) The X and Z increments per inch: DX = DZ = 0.4.

(d) The X and Z axis lengths: SX = SY = 10.

The variables are defined and thus plotted (all on one graph) from indices I1 to I2 when flag ICAL(J) > 0 for J = 3 to 8. Data to be plotted are stored in blank common arrays XX and ZZ. All data are checked to be sure they are within the plot scale values; if not, they are set equal to the minimum or maximum value. Subroutines LINE and SYMBOL are called to plot the data and print the legend on the graphs.

For parameter IP = 2, CPLT generates one plot of time (T or X array) in seconds versus angular velocity (Y) in radians per second and acceleration (Z) in radians per second squared. The time scaling is determined by the program as follows:

(a) the minimum time value (XMIN) is determined from the initial time value, X(1), adjusted to the nearest 0.01 less than X(1);

(b) the time increment per inch, DX = 0.02;

(c) The time axis length (SX) is determined from DX and the total range X(N) - XMIN

SX = FLOAT(IFIX((X(N) - XMIN)/DX) + 1).

The angular velocity and acceleration minimum and increment per inch scaling are set up by calling subroutine SCALE which checks the data and sets values accordingly. The velocity scale is printed on the left side of the graph and the acceleration scale on the right side. Subroutines LINE and SYMBOL are called to plot the data and print the legend on the graph.

For parameter IP = 3, CPLT generates one plot of time (T or X array) in seconds versus linear velocity (Y) in feet per second and acceleration (Z) in G's. The time scaling is

computed as per IP = 2 above. The velocity and acceleration are plotted using the same ordinate scale. The ordinate length SX is always 10 inches. The minimum value, YMIN, and the increment per inch, DY, are determined from the data. DY will always be 10, 20, or 30 depending on the total range required. If the total range is greater than 300, some of the data will be lost. All data are checked to be sure they are within the scale values; if not, they are set equal to the maximum or minimum value. Subroutine LINE is called to plot the data and subroutines SYMBOL and NUMBER are called to print the legend on the graph.

A flow chart for this routine is shown in Figure 2 and sample graphs are shown in Appendix D.

<u>Error Diagnostics:</u>	NONE
<u>Subroutines Required:</u>	AXIS, LINE, NUMBER, PLOT, SCALE, and SYMBOL (all are in the standard CALCOMP plot package).
<u>Argument List:</u>	T - array of time data points in velocity and acceleration plots.
	Y - array of velocity data points.
	Z - array of acceleration data points.
	IP -flag which determines the type of graph 1 - composite plot of variable displacement with respect to the sled 2 - angular velocity and acceleration 3 - linear velocity and acceleration
<u>Blank and Labeled COMMON Variables:</u>	JD - integer used to print parameter name in legend
	JR - integer used to print parameter name in legend
	N - number of data points used in velocity and acceleration plots
	NP - number of points used in least square fit

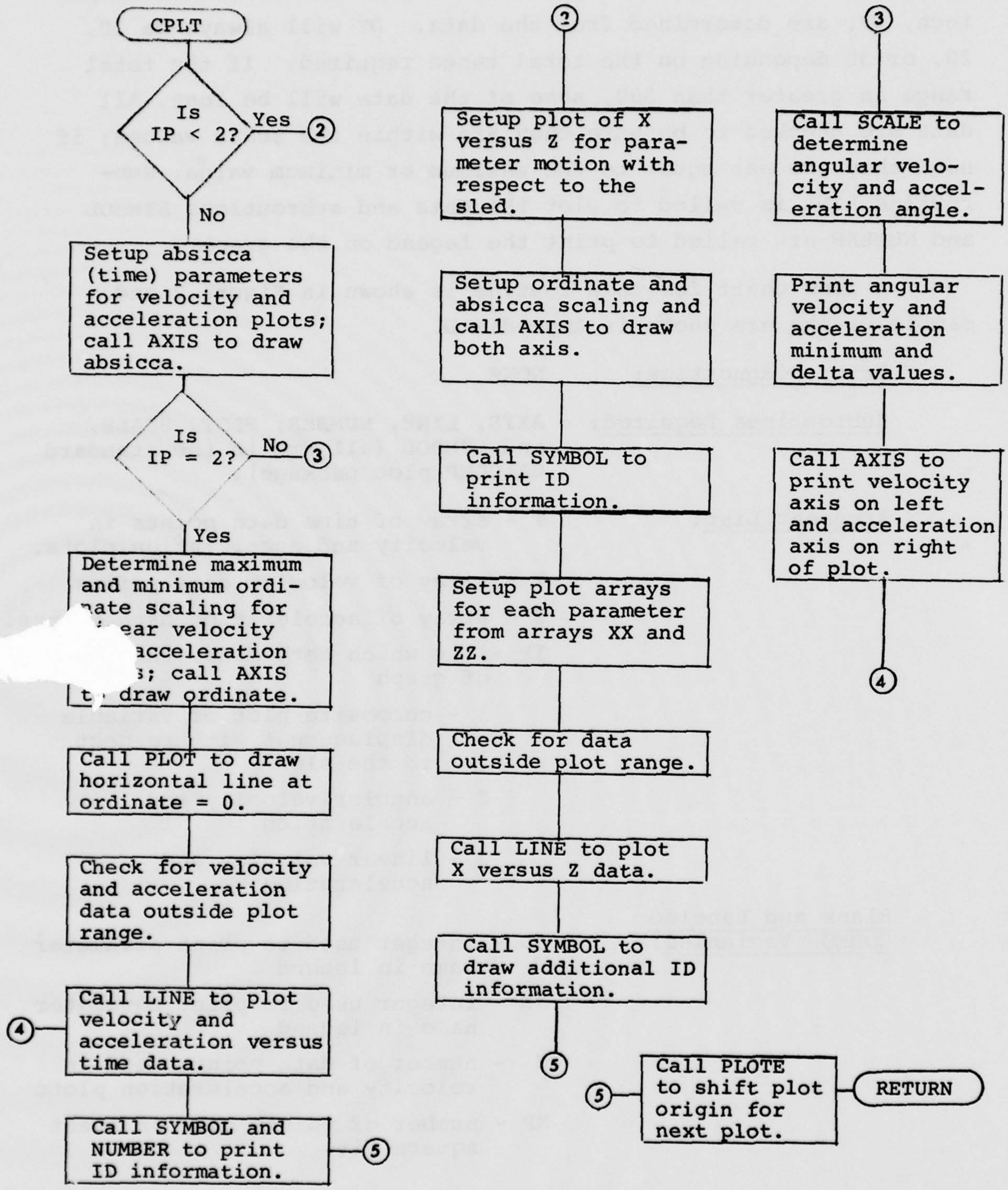


Figure 2. CPLT Flow Chart.

I1 - first point used in composite plot

I2 - last point used in composite plot

XX - array of X axis displacement data

ZZ - array of Z axis displacement data

ICAL - flag array which identifies defined data

ICAL(J) = 0 - J^{th} variable undefined

ICAL(J) = 1 - J^{th} variable is defined

HEADL - array containing variable names used in legend

TEST - test identification used in legend

IRX - flag used to setup composite plot X axis scale

Subroutine Length: 1363_8

Labeled Common Length: 23_8

Blank Common Length: 3456_8

2.1.2 Subroutine XM(X, Y, YC, N, NP)

Subroutine SM is a smoothing routine which computes a quadratic least square fit of NP dependent variable data points (Y) to compute each smoothed data point (YC). Since NP data points are used to compute each smoothed point, M data points are lost at the beginning and end of array YC, where

$$M = (NP - 1)/2.$$

Method

The first (MM) and last (NN) array indices for which YC(I) are computed are determined as follows:

$$MM = M + 1$$

$$NN = N - M$$

where M is defined above and N is the number of original displacement points in array Y. Subroutine QLSQ is called to compute the C_1, C_2, and C_3 coefficients for each of the I smoothed points which are then computed as follows:

$$YC(I) = C_1 * X(I)^2 + C_2 * X(I) + C_3.$$

A flow chart for this routine is shown in Figure 3.

Error Diagnostics: NONE

Subroutines Required: QLSQ

Argument List:

X = array of independent variable

Y = array of dependent variable

YC = array of smoothed dependent variable data

N = number of original displacement versus time data points

NP = number of points used to compute each smoothed data point

Subroutine Length: 113_8

2.1.3 Subroutine DERIV1 (X, YP, N, NP, ID)

Subroutine DERIV1 computes the derivative (YP) of the dependent variable Y. A quadratic least square fit of NP points is used to compute each derivative point; thus K points are lost at the beginning and end of array UP:

where

$$K = M + M * ID,$$

$$M = (NP - 1)/2,$$

ID = 1 for first derivative, and

ID = 2 for second derivative.

Note that for ID = 1, array Y contains displacement data which have already been smoothed using a quadratic least square fit over NP points; thus, M points have already been lost from the original displacement data. For ID = 2, array Y contains first derivative (velocity) data which starts at array location Y(2*M + 1).

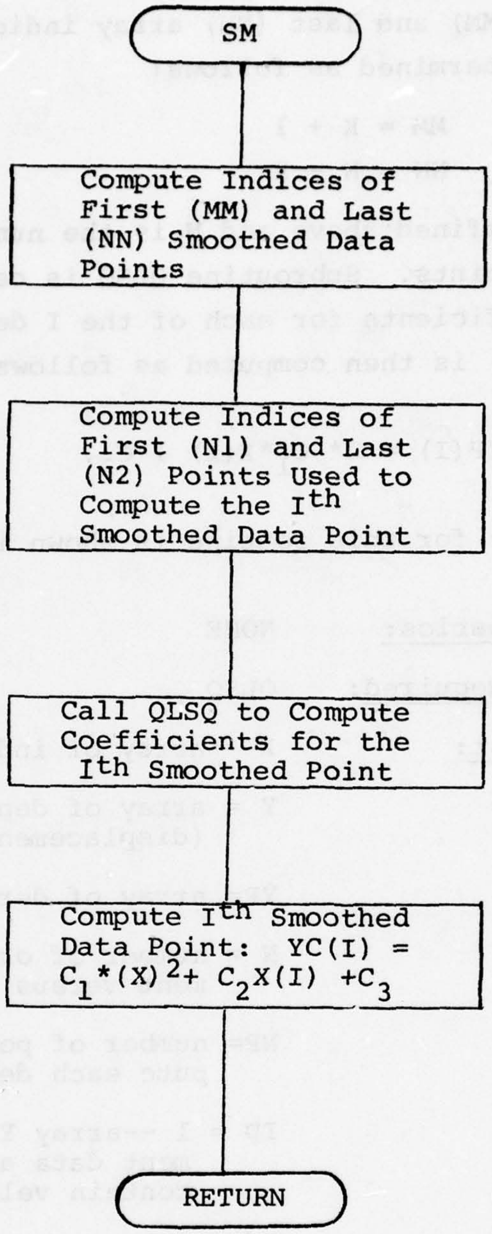


Figure 3. SM Flow Chart.

Method

The first (MM) and last (NN) array indices for which YP(I) are computed are determined as follows:

$$MM = K + 1$$
$$NN = N - K$$

where K and M are defined above and N is the number of original displacement data points. Subroutine QLSQ is called to compute the C_1, C_2, and C_3 coefficients for each of the I derivative points. The derivative YP(I) is then computed as follows:

$$YP(I) = 2* C_1*X(I) + C_2.$$

A flow chart for this routine is shown in Figure 4.

Error Diagnostics: NONE

Subroutine Required: QLSQ

Argument List:

X = array of independent variables

Y = array of dependent variables (displacement or velocity)

YP= array of derivative data

N = number of original displacement versus time data points

NP= number of points used to compute each derivative point

ID = 1 --array Y contains displacement data and array YP will contain velocity data

ID = 2 --array Y contains velocity data and array YP will contain acceleration data

Subroutine Length: 117_8

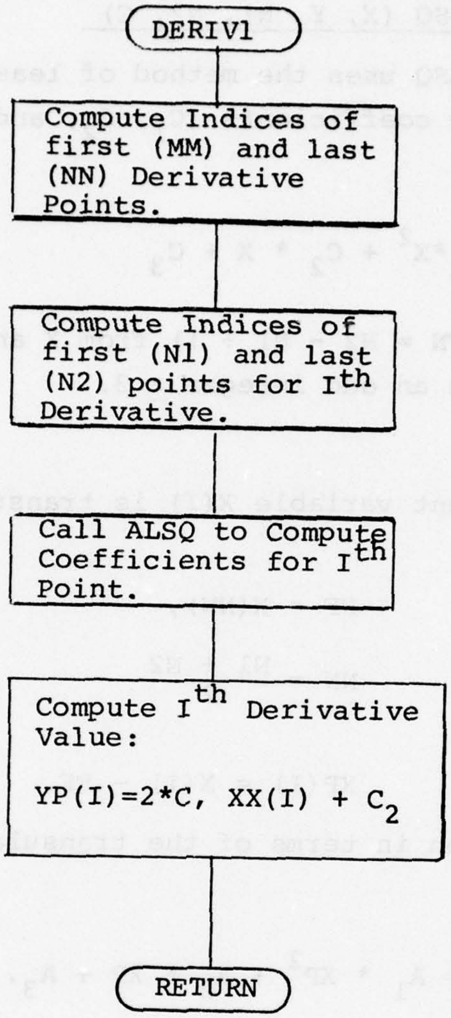


Figure 4. DERIV1 Flow Chart.

2.1.4 Subroutine QLSQ (X, Y, N1, N2, C)

Subroutine QLSQ uses the method of least squares to compute the quadratic coefficients (C_1, C_2, and C_3) for an equation of the form:

$$Y = C_1 * X^2 + C_2 * X + C_3$$

for FN data points (FN = N2 - N1 + 1) from X and Y array indices N1 to N2. FN must be an odd integer $\geq$ 3.

Method

The independent variable X(I) is transulated by a factor FF, where

$$FF = X(NN),$$

$$NN = \frac{N1 + N2}{2}$$

and

$$XP(I) = X(I) - FF.$$

The quadratic equation in terms of the transulated independent variable is

$$Y = A_1 * XP^2 + A_2 * XP + A_3.$$

The least square residuals are a minimum when the following equations are satisfied:

$$A_1 * \Sigma\, XP^4 + A_2 * \Sigma\, XP^3 + A_3 * \Sigma\, XP^2 = \Sigma\, XP^2 * Y$$

$$A_1 * \Sigma\, XP^3 + A_2 * \Sigma\, XP^2 + A_3 * \Sigma\, XP = \Sigma\, XP*Y$$

$$A_1 * \Sigma\, XP^2 + A_2 * \Sigma\, XP + A_3 * FN = \Sigma Y$$

where summations of XP and Y are computed for index I equal N1 to N2. Determinants are used to solve the above system of equations for the coefficients A_1, A_2, and A_3. The C_1, C_2, and C_3 coefficients are computed from A_1, A_2, and A_3 as follows:

$$C_1 = A_1$$

$$C_2 = A_2 - 2 * A_1 * FF$$

$$C_3 = A_3 + A_1 * FF^2 - A_2 * FF.$$

A flow chart for this routine is shown in Figure 5.

<u>Error Diagnostics:</u> NONE

<u>Subroutines Required:</u> NONE

<u>Argument List:</u> X = array of independent variables

Y = array of dependent variables

N1 = index of first point used in fit

N2 = index of last point used in fit

C = array containing quadratic coefficients.

<u>Subroutine Length:</u> 134_8

2.2 DATA PREPARATION FOR INPUT TO HIFPD

Preparation of data for input to HIFPD consists of editing and digitizing. The editing function provides film frame-to-time conversion and film frames coordinates to plane of motion coordinates conversion factors. The digitizing function provides the frame-by-frame "reading" of the projected film frame coordinates. The references, or "standards," required to process the data are film time reference pulses and surveyed fiducials in two planes normal to the optical axis of the camera.

Timing of the film frames was accomplished by calculating the average film speed over a span of approximately 150 frames. The procedure employed to determine the average film speed is described in Appendix B, Paragrah 3.2.

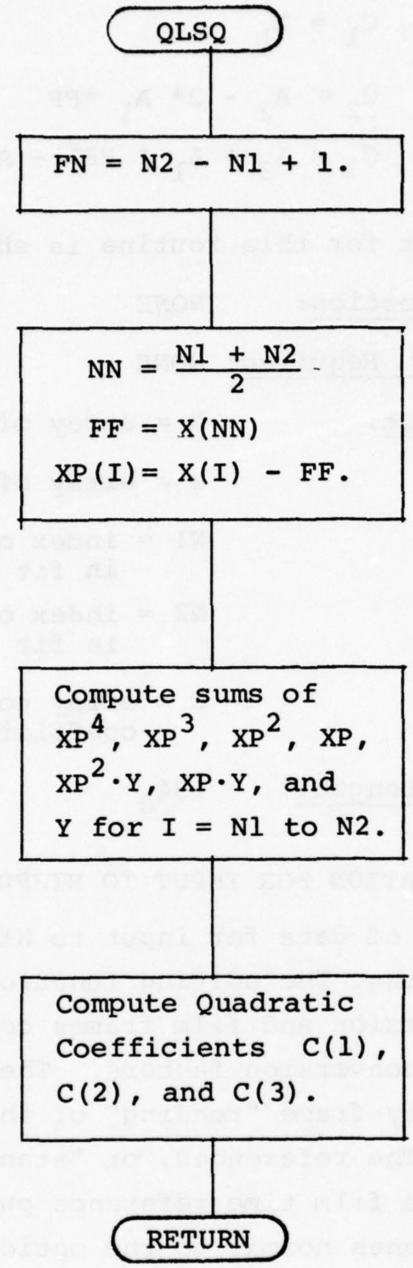


Figure 5. QLSQ Flow Chart.

The first frame in which the stroboscopic flash was observed was defined as t = 0. The strobe, initiated by a time synchronizing pulse which was also recorded on the magnetic tape recordings, actually gives t_o indication within 2.0 milliseconds accuracy at the nominal film speed of 500 frames per second with a 140° shutter. Since the flash is not observed in film frame -0001 and is observed in film frame 0000, it is apparent that it was initiated between the closing of the shutter on film frame -0001 and the closing of the shutter on film frame 0000. During most tests, the intensity of the first observed flash would indicate that it was initiated between the closing of the shutter on frame -0001 and the opening of the shutter on frame 000. If this is the case, the t_o indication could be considered to be accurate to 1.2 milliseconds, i.e.,:

$$\frac{360° - 140°}{360°} \times 2 \text{ msec} = 1.22 \text{ msec.}$$

Determination of conversion constants to be applied to the digitized readings of the anthropometric points on the subject required that the following be known.

a. The distance, normal to the plane of symmetry of the subject, from that plane to the left edge of the seat pan.

b. The distance, normal to the plane of symmetry of the subject from that plane, to the lexan panel above the side edge of the sled deck.

c. The distances, normal to the plane of symmetry of the subject, from that plane to the anthropometric points to be tracked.

d. That the optical axis of the primary camera was normal to the plane of symmetry of the subject.

e. The distances, between centers, of the fiducials mounted on the edge of the seat pan and of the fiducials mounted on the lexan panel.

The coordinates of the reference fiducials on the seat pan and the lexan panel were digitized five times. The readings of these coordinates were then averaged and the digital distance between the averaged coordinates of each pair was calculated. Dividing each of these digital distances by the corresponding measured dimension between fiducials yielded conversion constants, in terms of "counts per foot", in two planes normal to the optical axis. Having determined these conversion constants, and having measured the distance between the parallel planes in which the fiducials lay, the distance along the optical axis from the focal point of the lens to each of these planes and the plane of symmetry could then be calculated.

Prior to each test run the breadth of the subject was measured at each tracking fiducial location with an anthropometer. Assuming that each subject was symmetrical, the distance from the plane of symmetry to each tracking fiducial was defined as one-half the measured breadth of the subject of each fiducial location. Conversion constants for each plane parallel to the plane of symmetry, thus normal to the optical axis in which a tracking fiducial lay were then calculated by similar triangles.

The actual digitization of the photometric data was accomplished on a Producers Service Corporation model PVR film analyzer. The magnification factor of the projector was approximately 19.6, giving a projected frame image of 8 x 5.8-inches. The optical encoders were coupled to the reading cross-hairs through drive wires in such a manner that a displacement of either crosshair of one-inch caused the associated optical encoder to increase or decrease the reading by one thousand count.

The operator located the first frame in which the synchronizing flash was observed and reset the frame counter to 0000. The optical center of the film frame was found by

numerically bisecting the vertical and horizontal dimensions of the frame image. The operator then positioned the crosshairs over the range reference fiducial and depressed the record switch causing the frame number and coordinates of the fiducial to be punched into paper tape and typed on the carriage of the teletype terminal. He then proceeded to position the crosshairs over the seat reference fiducial. Again, depressing the record switch caused the coordinates to be recorded on the listing and the paper tape. In this manner he would proceed to each of the other points mentioned in Section 2.1, recording their coordinates, until all readings had been extracted from that frame.

After advancing the film to the next frame, the operator would check the coordinates of the range and seat fiducials. If the frame-to-frame variation of these coordinates exceeded ± 10 counts he would again locate the optical center of the film frame image before proceeding.

This procedure was repeated for each film frame until the subject appeared to have attained a static position after the impact.

The resulting paper tape was read into file on the CYBER 74 at the ASD computer center from the teletype terminal via data modem on a voice quality line, and the file was edited and corrected when necessary. At this time the control and title data were added to the file. This file was then copied on the card punch and printer as a time saving measure in case the disk file should be accidentally purged.

At this point the program HIFPD could have been attached and executed; however, the normal procedure was to obtain the card files and submit them in the batch mode on an overnight schedule. This permitted the connect time to be used for read-in and editing of additional data files.

A typical standard practice procedure detailing the data preparation is given in Appendix B.

SECTION 3
ANALYSIS OF DATA FROM TWO CAMERAS

Tracking of objects moving through the space of a three-dimensional coordinate system, using analysis of phototheodolite recordings, has been accomplished with a great degree of accuracy for many years. The recognized requirements to accomplish these analyses are quite simple, viz., cameras at two or more tracking stations with precisely synchronized shutters, time for frame signal numbers, azimuth and elevation indicators, and relatively massive mounted systems having provision for leveling and plumbing the cameras. Additionally, the locations of the camera mounts must be accurately surveyed.

When one attempts to track the motion of several points with respect to a three-dimensional coordinate system on a moving vehicle, all the simplicity of the large tracking range disappears, and an entirely new set of problems confront the investigator. Camera weight must be kept to a minimum and light-weight, rigid mounting systems must be devised. Actual shutter synchronization is not practical at the high film transport speeds necessary to record the motion. The precise locations and orientations of the cameras are subject to change, not only from test to test, but even during a test.

To solve the above mentioned problems, two processes were developed, one to accurately determine the location and orientation of a camera with respect to the coordinate system, and the second to track the coordinates of identified points with respect to the origin of the coordinate system.

The processing programs developed to accomplish these solutions, "POOCH" and "SLED" respectively, are described in the following discussions.

3.1 CAMERA LOCATION AND ORIENTATION

The value of a program which can determine the location, orientation, and focal length of a camera by examination of the film frame images of a set of accurately surveyed object prints is rather obvious. Regardless of the care exercised, if a large enough amount of camera data is taken, sooner or later a camera will be jarred or moved or a set of camera data will be misplaced or mislabeled, or a camera mounted aboard a moving vehicle may vibrate on its mount and one may wish to do a frame by frame correction of the camera position and orientation.

There are seven unknows to be determined in this problem. They are the location of the camera focal point (xx, yy, zz), the camera focal length (ff), and azimuth angle (th) and the elevation angle (ph) of the camera optical axis, and the angle (α) by which the camera is tilted from horizontal about its optical axis.

Before proceeding with the main theme, a comment must be made regarding the relationship between camera focal length and the distance of the camera from the scene. There is a misconception that if a camera of one focal length is used to photograph a scene, a camera of a shorter focal length will photograph precisely the same scene if taken somewhat closer. That is not true in general. It is true only in the case that every point of the scene being photographed lies in a plane normal to the optical axes of the two cameras.

Although not physically correct, one loses nothing mathematically by assuming that the film frame is interposed between the camera focal point and the scene and that film frame images are created by light rays emanating from the object points and passing through the film to the camera focal point. See Figure 6.

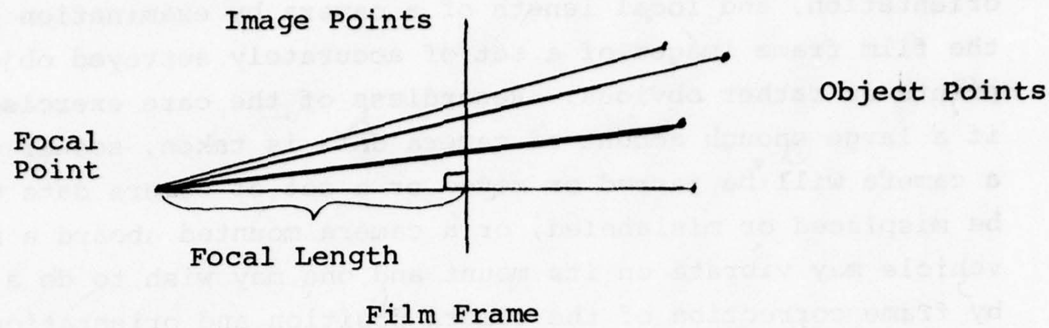


Figure 6.

Assume first that a camera of focal length ff lies at a distance d from a scene composed of two object points at heights ha and hb above its optical axis. See Figure 7.

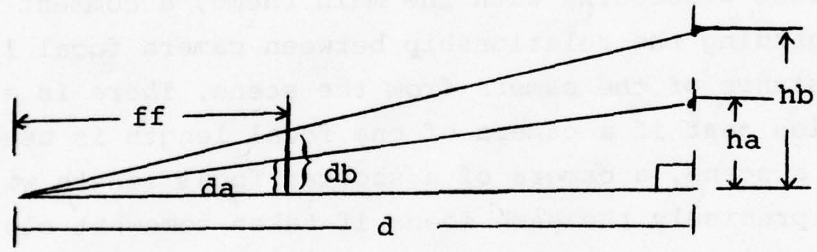


Figure 7.

Both object points lie in a plane normal to the camera optical axis. By similar triangles

$$\frac{d}{ff} = \frac{ha}{da} = \frac{hb}{db}$$

If k > 0, by the equation

$$\frac{kd}{kff} = \frac{d}{ff} .$$

It is obvious a camera at distance kd from the object points with a focal length of kff gives exactly the same image points at the original camera at distance d with focal length ff. Thus, if the object points are all in a plane normal to the camera optical axis, it is impossible to determine from the image and object point locations <u>both</u> the camera focal length and its distance from the scene.

If the two object points have <u>different</u> spacings along the camera optical axis, the situation is quite different. See Figure 8.

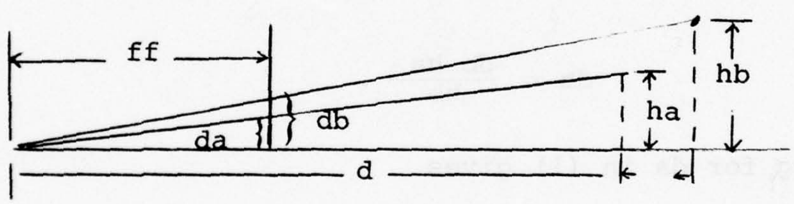


Figure 8.

In Figure 8 the project of the two object points on the camera optical axis are spaced a distance e apart where e is known and e ≠ 0. da, db, ha, and hb are known. ff and d are unknown.

Again by similar triangles

$$(1) \quad \frac{d}{ha} = \frac{ff}{da}$$

$$(2) \quad \frac{d + e}{hb} = \frac{ff}{db}.$$

From (1) $$d = \frac{ha\ ff}{da}.$$

Substituting in (2) $$\frac{\frac{ha\ ff}{da} + e}{hb} = \frac{ff}{db}.$$

or $$\frac{ha\ ff + da\ e}{da\ hb} = \frac{ff}{db}$$

or $$db\ ha\ ff + da\ db\ e = da\ hb\ ff.$$

$$(3) \quad (da\ hb - db\ ha)\ ff = da\ db\ e.$$

Now if it is assumed that da hb - db ha = 0, we get

$$db = \frac{db\ ha}{hb}.$$

Substituting for da in (1) gives

$$\frac{d}{ha} = \frac{ff}{\left(\frac{db\ ha}{hb}\right)} = \frac{hb\ ff}{db\ ha}.$$

or $$\frac{ff}{db} = \frac{ha}{hb}\,\frac{d}{ha} = \frac{d}{hb}.$$

But (2) is $$\frac{ff}{db} = \frac{d + e}{hb}.$$

Therefore, $$\frac{ff}{db} = \frac{d + e}{hb} = \frac{d}{hb}$$

$$\frac{e}{hb} = 0$$

$e = 0$ contrary to the problem statement.

Therefore in (3) the coefficient of ff $\neq$ 0 and we may solve for ff:

$$(4)\quad ff = \frac{da\ db\ e}{da\ hb - db\ ha}\ .$$

Substituting for ff in (1) gives

$$(5)\quad d = \frac{ha}{da}\ ff = \frac{ha\ db\ e}{da\ hb - db\ ha}$$

and we have in (4) and (5) unique solutions for both ff and d.

However, two object points with different spacings along the camera optical axis are not sufficient to locate the camera becasue the camera may be rotated in space about an axis between two object points without disturbing any of the geometrical relationships in Figure 8. See Figure 9.

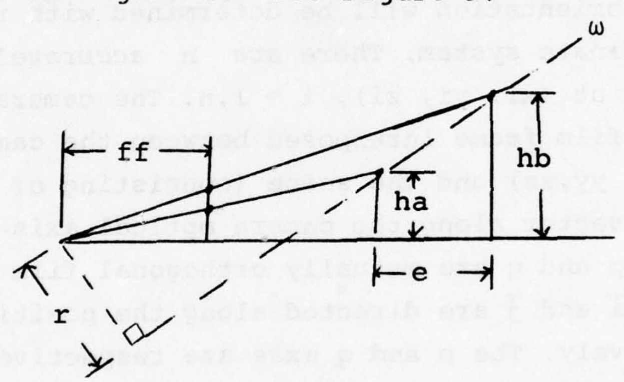


Figure 9.

Figure 9 shows the axis of rotation ω and the radius r of the circle the camera focal point can describe in space. A third object point lying on the axis between the first two object points does not help to locate the camera. To be of help, the third object point must lie at a distance from the line passing through the other two object points. The conclusion is then that in order to completely locate, orient, and determine the focal length of a camera, one requires an absolute minimum of three accurately surveyed object points forming a nondegenerate triangle whose plane was not normal to the camera optical axis when the picture was taken.

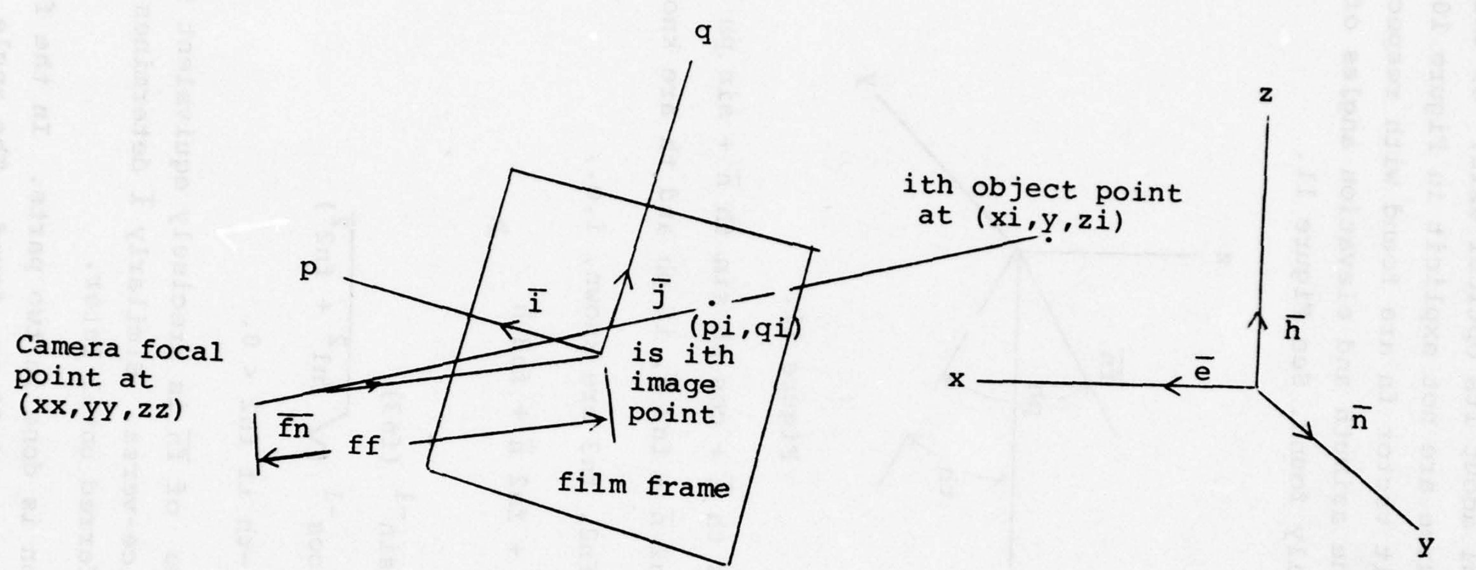
With the minimum of three object points, small reading errors can easily distort the solution. In practice it is best to have at least five to eight object points with a good spread normal to the camera optical axis and significant differences in spacing along the optical axis.

The above discussion demonstrating the necessity of at least three object points is in no way indicative of the solution scheme used in the camera location program. The analysis used in the program will now be discussed.

3.1.1 Mathematical Models

The problem is modeled or indicated in Figure 10. The principal coordinate system is a right hand mutually orthogonal x y z coordinate system. Unit vectors $\bar{e}$, $\bar{n}$, and $\bar{h}$ are directed along the positive x, y, and z axis respectively. The camera position and orientation will be determined with respect to the x, y, z coordinate system. There are n accurately surveyed object points at (xi, vi, zi), i = 1,n. The camera itself is modeled as a film frame interposed between the camera focal point at (xx, yy,zz) and the scene (consisting of n object points). $\overline{fn}$ is a unit vector along the camera optical axis normal to the film frame. p and q are mutually orthogonal film frame axes. Unit vectors $\bar{i}$ and $\bar{j}$ are directed along the positive p and q axes respectively. The p and q axes are respectively horizontal and vertical <u>with respect to the film frame</u>. Throughout this report ff will be referred to as the camera focal length, but it is actually the product of the true camera focal length and the magnification of the film frame reader. To each of the object points (xi, yi, zi), i=1, n corresponds to a film frame image point with known film frame coordinates (pi, qi), i= 1,n. The unit vectors $\overline{fn}$, $\bar{i}$, and $\bar{j}$ form a mutually orthogonal right hand set, i.e., $\bar{j} = \overline{fn} \times \bar{i}$.

To reiterate, the unknowns in this problem are the location of the camera focal point (xx, yy,zz), the focal length ff, the azimuth angle, th, and the elevation angle, ph, of the camera optical axis, and the angle, γ , by which the camera is



q
z
ith object point
at (xi,y,zi)
p
ī
j̄
(pi,qi)
is ith
image
point
Camera focal
point at
(xx,yy,zz)
fn
ff
film frame
x
ē
h̄
n̄
y

Figure 10.

tilted from horizontal about its optical axis. Of these seven unknowns, the last three are not explicit in Figure 10. If the components of the unit vector fn are found with respect to the x y z system, then the azimuth and elevation angles of the camera optical axis are easily found. See Figure 11.

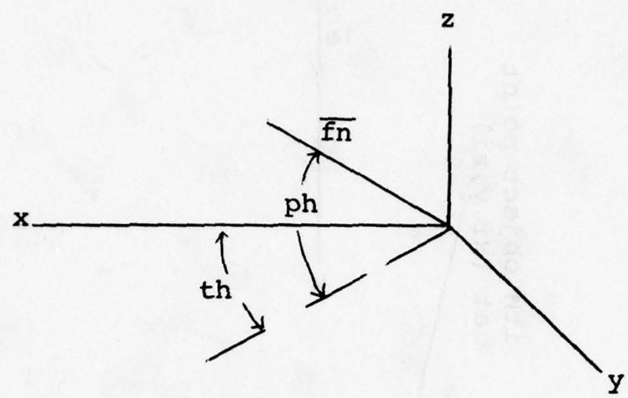


Figure 11.

$$\overline{fn} = \cos ph \cos th\ \bar{e} + \cos ph \sin th\ \bar{n} + \sin ph\ \bar{h}$$

$$= fn1\ \bar{e} + fn2\ \bar{n} + fn3\ \bar{h}, \text{ if ph and th are known.}$$

Similarly, if fn1, fn2, fn3 are known, i.e.,

$$\overline{fn} = fn1\ \bar{e} + fn2\ \bar{n} + fn3\ \bar{h}$$

Then

$$ph = \sin^{-1} (fn3)$$

$$th = \cos^{-1} \left(\sqrt{fn1^2 + fn2^2}\right)$$

$$th = -th \text{ if } fn2 < 0.$$

Therefore, knowledge of $\overline{fn}$ is precisely equivalent to knowledge of th and ph and vice-versa. Similarly $\bar{I}$ determines γ but the details will be deferred until later.

The solution is done in two parts. In the first part the unknowns xx,yy,zz, and ff are found. The angle subtended at the camera focal point by the ith and jth image points is $\ddot{g}y$ ($j \neq i$). See Figure 12.

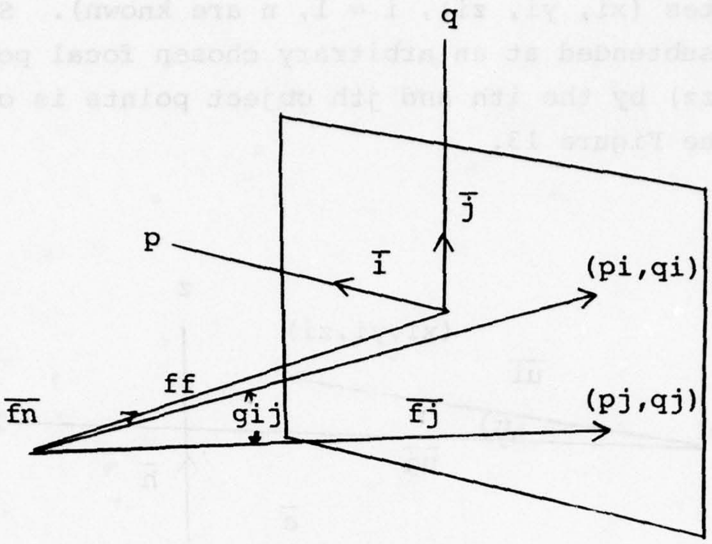


Figure 12.

Although the components of the unit vectors $\overline{fn}$, $\overline{i}$, and $\overline{j}$ are not known at present with respect to the xyz system, it is known that they form a right hand mutually orthogonal set. So vectors $\overline{fi}$ and $\overline{fj}$ to the ith and jth image points may be written:

$$\overline{fi} = ff\ \overline{fn} + pi\ \overline{i} + qi\ \overline{j}$$

$$\overline{fj} = ff\ \overline{fn} + pj\ \overline{i} + qj\ \overline{j}$$

Then the angle $g\ddot{y}$ subtended by $\overline{fi}$ and $\overline{fj}$ at the camera focal point is:

$$g\ddot{y} = \cos^{-1}\left(\frac{\overline{fi} - \overline{fj}}{/fi/fj/}\right)$$

$$g\ddot{y} = \cos^{-1}\left\{\frac{ff^2 + pi\ pj + qi\ qj}{(ff^2 + pi^2 + qi^2)^{1/2}\ (ff^2 + pj^2 + qj^2)^{1/2}}\right\}$$

and the <u>only unknown</u> appearing in the equation for $\ddot{gy}$ is ff. (All image point coordinates (pi, qi), i = 1, n and all object point coordinates (xi, yi, zi), i = 1, n are known). Similarly, the angle $\ddot{hy}$ subtended at an arbitrary chosen focal point location (xx, yy, zz) by the ith and jth object points is obtained as follows. See Figure 13.

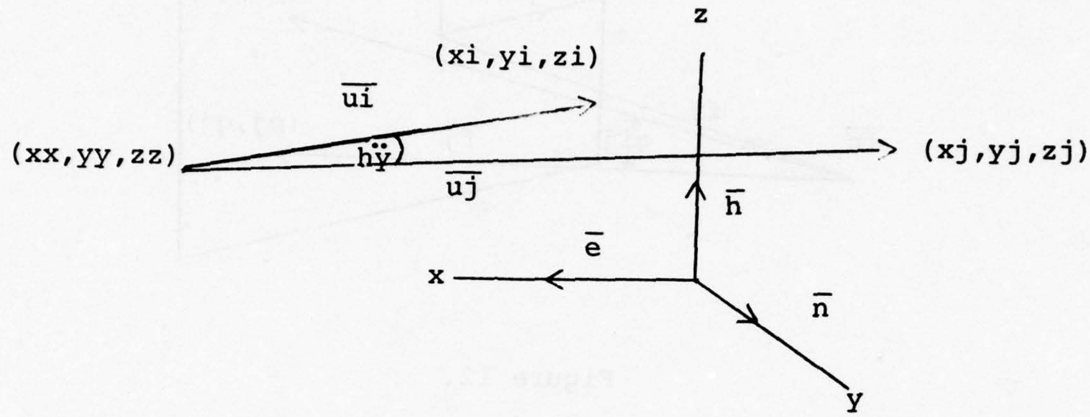


Figure 13.

$$\ddot{hy} = \cos^{-1}\left(\frac{\overline{ui}\ .\ \overline{uj}}{/\overline{ui}/\ /\overline{uj}/}\right)$$

where

$$\overline{ui} = (xi - xx)\ \bar{e} + (yi - yy)\ \bar{n} + (zi - zz)\ \bar{h}$$

$$\overline{uj} = (xj - xx)\ \bar{e} + (yj - yy)\ \bar{n} + (zj - zz)\ \bar{h}$$

$$\ddot{hy} = \cos^{-1}\left\{\frac{(xi-xx)(xj-xx) + (yi-yy)\ (jy-yy) + (zi-zz)\ (zj-zz)}{[(xi-xx)^2+(yi-yy)^2+\ (zi-zz)^2]^{1/2}\ \ [(xj-xx)^2+(yj-yy)^2+(zj-zz)^2]^{1/2}}\right\}$$

and the only unknowns in the $\ddot{hy}$ equation are xx, yy, and zz.

Thus we have

$$\ddot{gy} = \ddot{gy}\ (ff),$$

a function of ff, and

$$\ddot{hy} = \ddot{hy}\ (xx,yy,zz),$$

a function of focal point position. If the correct values of ff, xx,yy, zz are inserted in these two equations, we should have

$$\ddot{gy}(ff) = \ddot{hy}\ (xx,yy,zz).$$

Define $\ddot{erry} = (\ddot{gy} - \ddot{hy})^2$, and

$$\ddot{erry} = \ddot{erry}\ (ff,xx,yy,zz).$$

Then the total error err taken over all possible pairs of points is, for an arbitrary choice of ff, xx, yy, zz

$$err = \sum_{i=1}^{n-1} \sum_{j=1}^{n} errij\ (=err(ff,xx,yy,zz)).$$

Then we should have at the correct values ff, xx, yy, zz err = 0.

Due to the film frame reading errors, errors in the surveyed object points, lens distortion, err $\neq$ 0 at the correct value of ff, xx, yy, zz, but it will attain a relative minimum there. Let fp and fq be numbers chosen so as to be generous bounds on the true focal length ff. $0 < fp < ff < fq$. Let (xq,yq,zq) be the x y z values that minimize err (fq , x, y, z), that is, err (fq , xq, yz,zq) is the smallest value of err that can be obtained for focal length of fq. Similarily, let err (fp,xp,yp,zp) be the minimum of err for focal length fp. As one would expect, the optimized position of the focal point is closer to the scene for the smaller value of focal length. See Figure 14.

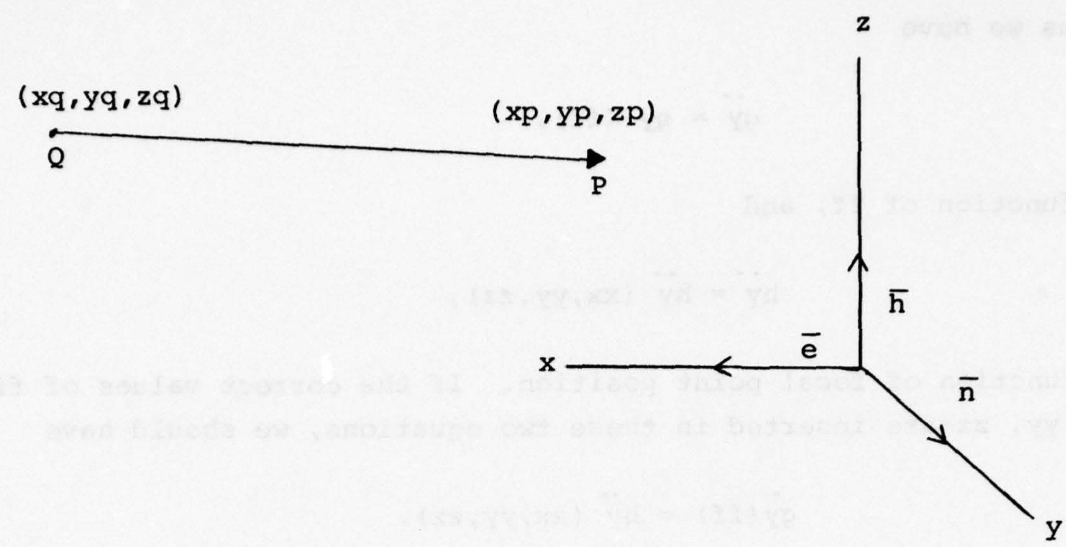


Figure 14.

Let fs be any focal length value such that fp < fs < fq. Let (xs, ys, zs) be that point that minimizes err, i.e, err (fs, xs,yx, az) is a minimum for focal length fs. Then the following proportions furnish excellent estimates of xs, ys, and zs for a given focal length fs.

$$\frac{xs - xp}{xq - xp} = \frac{fs - fp}{fq - fp}$$

$$\frac{ys - yp}{yq - yp} = \frac{fs - fp}{fq - fp}$$

$$\frac{zs - zp}{zq - zp} = \frac{fs - fp}{fq - fp} .$$

In other words, as fs varies from fp to fq, it is very nearly true that the point (xs, ys, zs) moves a proportional amount of the distance from p to q along the line segment. Solving the equation for (xs, ys, zs) gives

$$xs = xp + (xq - xp)\ \frac{fs - fp}{fq - fp}$$

$$ys = yp + (yq - yp)\ \frac{fs - fp}{fq - fp}$$

$$zs = zp + (zq - zp)\ \frac{fs - fp}{fq - fp}\ .$$

The application of these equations will be discussed shortly.

A graph of the minimized value of err versus focal length has the form illustrated in Figure 15.

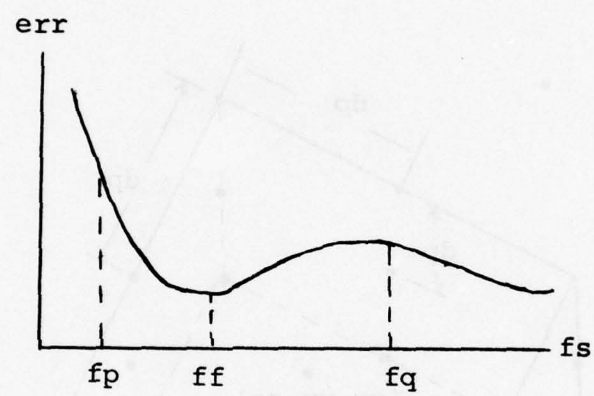


Figure 15.

The relative minimum of err for fs [fp,fq] occurs at ff. Of course as fs $\rightarrow \infty$, both the scene and the film frame shrink to points with respect to the camera focal point, so err will approach the fs axis asymptotically from above.

When data is input to the program, rough estimates of ff, xx, yy, zz are read in. Also input are two generous bounds on ff, fp, and fq where $0 < fp < ff < fq$. The first step is to locate the points P and Q. Assume we are searching for point P in Figure 14, that point (xp, yp, zp) that makes err (fp, xp, yp, zp) a minimum for focal length fp.

A cube of 27 points is centered at the input point (xx, yy, zz). See Figure 16. The cube's edges are parallel to the principal coordinate system axes and it has edge length 2 dp where dp is an internally defined value. Err (fp, x, y, z) is computed at each of the cube points. Then (xx, yy, zz) are set equal to the coordinates of that point that resulted in the smallest value of err. Then a new cube is constructed centered on a new point (xx, yy, zz) and the process repeated. Ultimately a cube is found whose center point gives the smallest value of

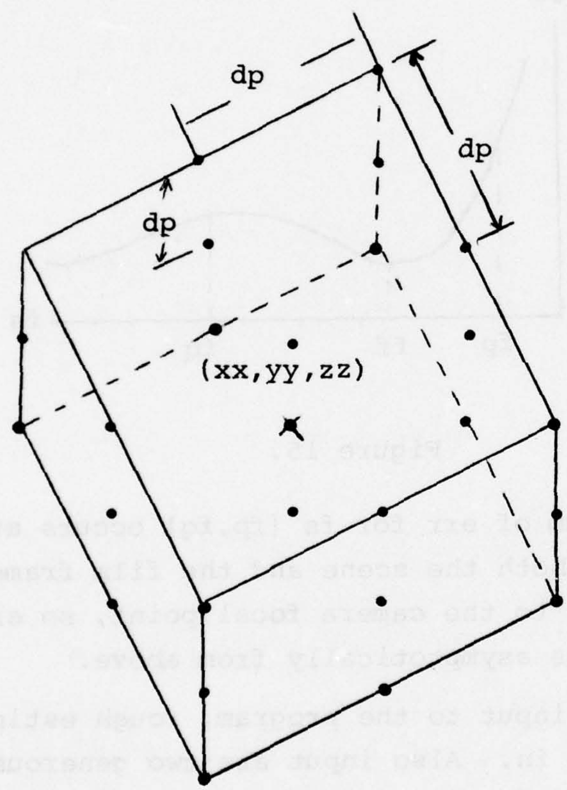


Figure 16.

err. This cube then contains the optimum point. dp is then reduced to a tenth of its previous value, a new smaller cube centered on the minimum point is constructed and the whole process is repeated again. This iterative process is terminated when dp falls below a certain test value. Then (xp, yp, zp) is set equal to the coordinates of the last minimum point determined. This is the process used to determine for ff = fp, and ff = fq the best camera focal point locations (xp, yp, zp) and (xq, yq, zq) respectively. The above process is capable of moving the focal point many feet through space from a grossly inaccurate first estimate to the final optimizing point. But this iteration is quite time consuming. For example, if 20 cubes are required to locate an optimum point, it requires the computation of err at 20 x 27 = 540 points. And if there are, say, 9 object points, there are $\frac{9 \times 8}{2} = 36$ values of $h\dot{y}$ and $g\dot{y}$ that must be computed, differenced, squared, and added for each computation of err. For this reason, the above process is not used to make the final determination of the focal length. Rather for each value of focal length fs used in this determination, a very nearly optimum point for optimizing err is gotten from the three proportions mentioned earlier on page 38.

$$xs = xp + \frac{fs - fp}{fq - fp}(xq - xp)$$

$$ys = yp + \frac{fs - fp}{fq - fp}(yq - yp)$$

$$zs = zp + \frac{fs - fp}{fq - fp}(zq - zp).$$

Then err is minimized at fs by checking points very close to (xs, ys, zs) by a simpler, faster process to be described shortly. To find the correct value of ff we set

$$dist = (fq - fp) / 6.0.$$

Then fs is set equal to fq + i dist, i = 0, 1, 2, ..., 6 in succession and the minimum error values err found for each fs.

Say it occurs at fs = fso. Then we redefine fq = fso + dist and fp = fso - dist, set dist = (fq - fp)/ 6.0 and go through the same process all over again. This is continued until dist falls below a present value. Then ff is set equal to the last fs computed and (xx, yy, zz) to the last optimized value of (xs, ys, zs). This is the final step in solving for these first four of the seven unknowns in this problem.

In order to construct the routine which is used to optimize the initial values of (xs, ys, zs) gotten from the three equations above, reference must be made to Figure 17.

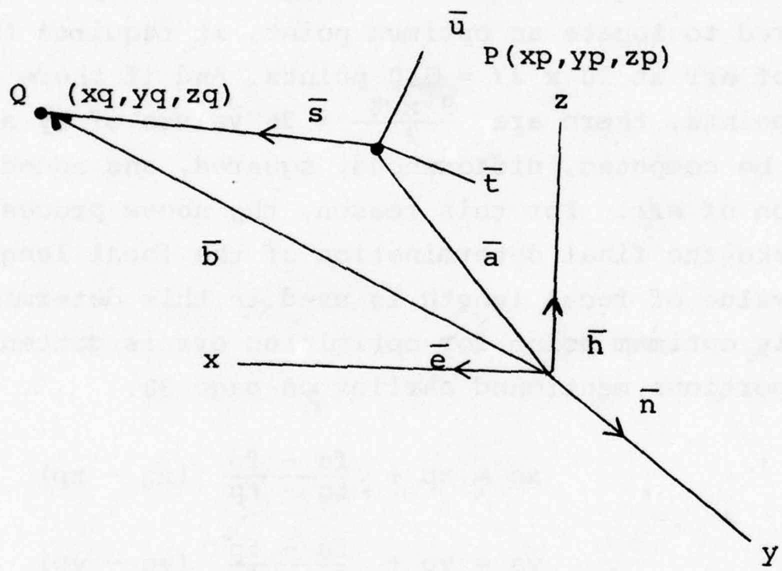


Figure 17.

$$\bar{a} = fp\ \bar{e} + yp\ \bar{n} + gp\ \bar{h}$$

$$\bar{b} = xq\ \bar{e} + yq\ \bar{n} + zq\ \bar{h}.$$

The unit vectors defined as follows are the directions in space along which the iterative procedure searches in order to optimize the initial values of (xs, ys, zs) to find the minimum value of err for focal length fs.

$$\bar{s} = \frac{\bar{b} - \bar{a}}{|\bar{b} - \bar{a}|}$$

$$\bar{t} = \frac{\bar{h} \times \bar{s}}{|\bar{h} \times \bar{s}|}$$

$$\bar{u} = \bar{s} \times \bar{t}\ .$$

Defined in this way, $\bar{s}$, $\bar{t}$, and $\bar{u}$ form a right hand set of mutually othogonal unit vectors with $\bar{s}$ lying along the line segment between points p and q. A maximum of six computations of err are required for each iteration as opposed to the 27 required for the cube search. The order in which the points are tried is indicated in Figure 18.

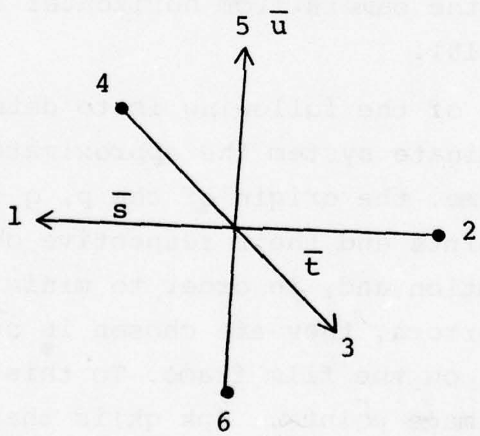


Figure 18.

The value of err is known at the junction of $\bar{s}$, $\bar{t}$, and $\bar{u}$ (referred to as the center point). The points 1 through 6 are tried in order. If the value of err at any of points 1 through 6 is smaller than that at the center point, the next step will be in the same direction. For example, if point 3 should be the first point to yield a smaller value of err than that at the center point, the routine will continue to step in the t direction so long as successively smaller values of err are obtained.

Similarly as for the cube search, when all of points 1 through 6 yield a higher value of err than that at the center point, the step size is reduced and the whole process repeated. This continues until the step distance falls below a certain present value.

The location of the camera focal point and its focal length have now been found to be (xx, yy, zz) and ff respectively. As mentioned previously, the determination of the components of the unit vectors $\overline{fn}$ and $\bar{i}$ with respect to the principal coordinate system is equivalent to finding the azimuth and elevation of the optical axis and the tilt angle of the camera from horizontal about the optical axis (refer to Figure 10).

The whole point of the following is to determine with respect to the principal coordinate system the approximate location of the center of the film frame, the origin of the p, q film frame coordinate system. Three image points and their respective object points are required to get a solution and, in order to minimize the effects of reading and other errors, they are chosen in such a way as to form a large triangle on the film frame. To this end, three sorts are performed on the image points. (pk qk)is that point farthest from the film frame origin. (pl, ql) is that point farthest from (pk, qk). (pm,qm) is that point the sum of whose distances from (pk,qk) and pl,ql) is the greatest. See Figure 19.

The vectors from the camera focal point to the kth, lth, and mth image points are respectively:

$$\overline{skc} = ff\ \overline{fn} + pk\ \overline{i} + qk\ \overline{j}$$

$$\overline{slc} = ff\ \overline{fn} + pl\ \overline{i} + ql\ \overline{j}$$

$$\overline{smc} = ff\ \overline{fn} + pm\ \overline{i} + qm\ \overline{j}$$

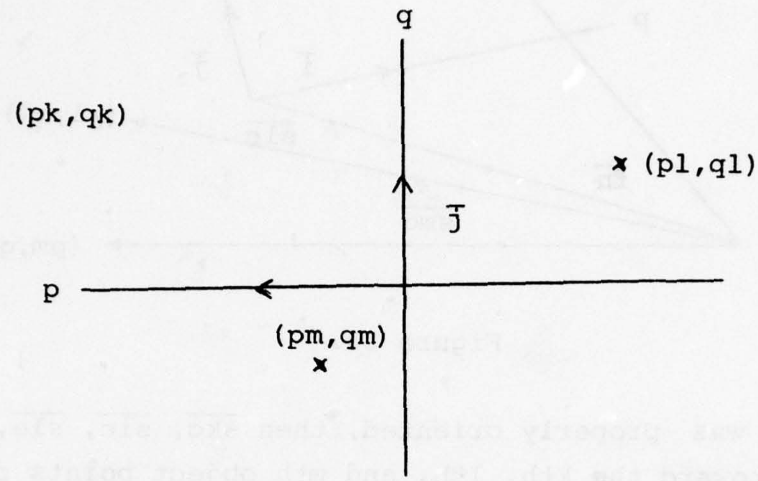


Figure 19.

where these three vectors have been written in terms of their components with respect to these as-yet-unknown unit vectors, $\overline{fn}$, $\overline{i}$, $\overline{j}$ of the camera coordinate system. The vector magnitudes are

$$dfk = (ff^2 + pk^2 + qk^2)^{1/2}$$

$$dfl = (ff^2 + pl^2 + ql^2)^{1/2}$$

$$dfm = (ff^2 + pm^2 + qm^2)^{1/2} .$$

See Figure 20.

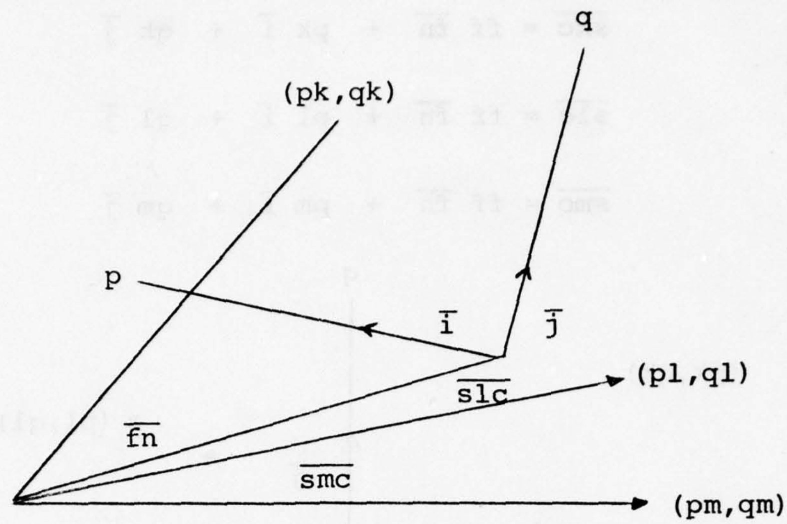


Figure 20.

If the camera was properly oriented, then $\overline{skc}$, $\overline{sic}$, $\overline{sle}$, and $\overline{sme}$ should point toward the kth, lth, and mth object points respectively. Unit vectors $\overline{nfa}$, $\overline{nfb}$, and $\overline{nfc}$ pointing at the kth, lth, and mth object points respectively obtained as follows:

$$\overline{fa} = (xk - xx)\,\overline{e} + (yk - yy)\,\overline{n} + (zk - zz)\,\overline{h}$$

$$\overline{fb} = (xl - xx)\,\overline{e} + (yl - yy)\,\overline{n} + (zl - zz)\,\overline{h}$$

$$\overline{fc} = (xm - xx)\,\overline{e} + (ym - yy)\,\overline{n} + (zm - zz)\,\overline{h}$$

$$dam = /\overline{fa}/ = [(xh - xx)^2 + (yk - yy)^2 + (zk - zz)^2]^{1/2}$$

$$dbm = /\overline{fb}/ = [(xl - xx)^2 + (yl - yy)^2 + (zl - zz)^2]^{1/2}$$

$$dcm = /\overline{fc}/ = [(xm - xx)^2 + (ym - yy)^2 + (zm - zz)^2]^{1/2}$$

$$\overline{nfa} = \overline{fa}/dam$$

$$\overline{nfb} = \overline{fb}/dbm$$

$$\overline{nfc} = \overline{fe}/dem.$$

Multiplying these unit vectors by the magnitudes of $\overline{skc}$, $\overline{slc}$, and $\overline{smc}$ gives $\overline{sk}$, $\overline{sl}$, and $\overline{sm}$ below

$$\overline{sk} = dfk\ \overline{nfa}$$

$$\overline{sl} = dfl\ \overline{nfb}$$

$$\overline{sm} = dfm\ \overline{nfc}.$$

The vectors $\overline{sk}$, $\overline{sl}$, and $\overline{sm}$ so defined are known with respect to the principal program coordinate system. More over, they are very nearly equal to $\overline{skc}$, $\overline{slc}$, and $\overline{smc}$; that is:

$$sk \simeq skc$$

$$sl \simeq slc$$

$$sm \simeq smc.$$

See Figure 21.

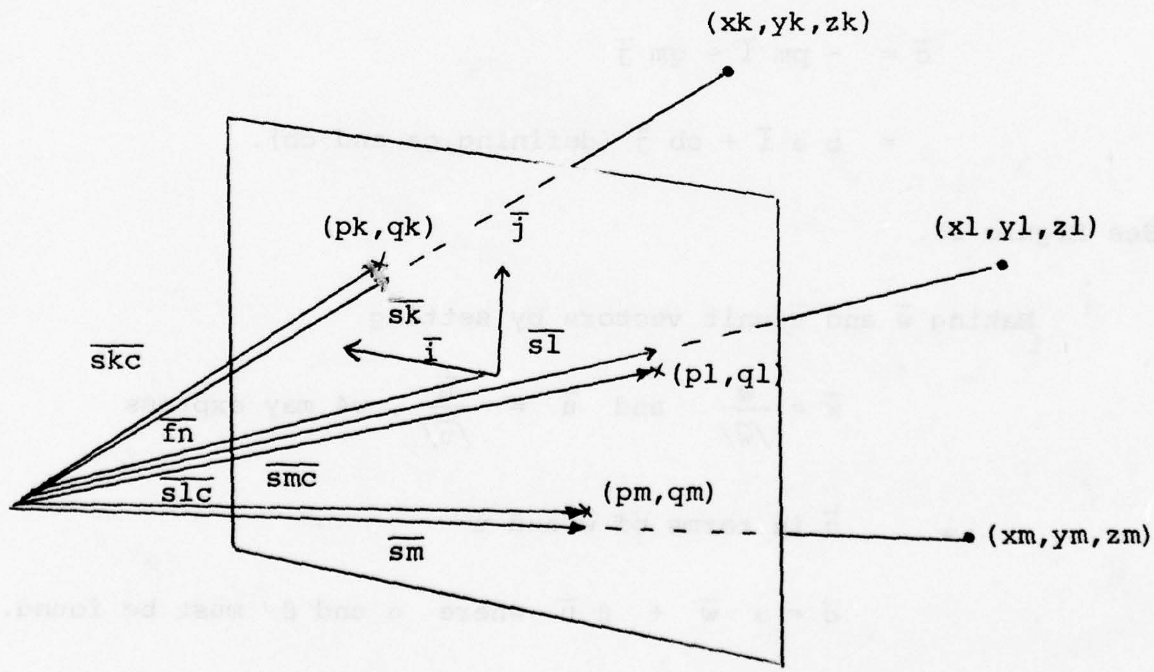


Figure 21.

Were it not for the various errors, the above equivalence would be exact and the unknown unit vectors $\overline{fn}$, $\overline{i}$, and $\overline{j}$ could be solved for directly. The solution could be done anyway, but the resulting solution vectors $\overline{fn}$, $\overline{i}$, and $\overline{j}$ would in general be neither unit vectors nor would they be mutually perpendicular. Of course, the resulting system could be made orthonormal algebraically, but it was not known at the time how large errors would be nor how much distortion would be produced by the errors. It was decided to take advantage of the approximate vector equivalence above in the following manner in order to determine $\overline{fn}$, $\overline{i}$, and $\overline{j}$.

Let

$$\overline{w} = \overline{skc} - \overline{smc} = (pk - pm)\,\overline{i} + (qk - qm)\,\overline{j}$$

$$\overline{u} = \overline{slc} - \overline{smc} = (pl - pm)\,\overline{i} + (ql - qm)\,\overline{j}.$$

A vector $\overline{c}$ from the image point in to the center of the film frame is

$$\overline{c} = -\,pm\,\overline{i} - qm\,\overline{j}$$

$$= c\,a\,\overline{i} + cb\,\overline{j} \text{ (defining ca and cb).}$$

See Figure 22.

Making $\overline{w}$ and $\overline{u}$ unit vectors by setting

$$\overline{w} = \frac{\overline{w}}{/\overline{w}/} \quad \text{and} \quad \overline{u} = \frac{\overline{u}}{/\overline{u}/}$$, w4 may express

$\overline{c}$ in terms of $\overline{w}$ and $\overline{u}$

$$\overline{c} = \alpha\,\overline{w} + \beta\,\overline{u} \text{ where } \alpha \text{ and } \beta \text{ must be found.}$$

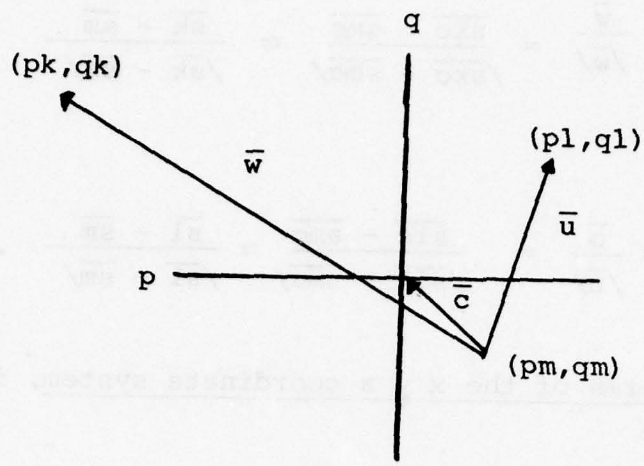


Figure 22.

Equating $\overline{i}$ and $\overline{j}$ components gives:

$$\alpha\, wa + \beta\, ua = ca$$

$$\alpha\, wb + \beta\, ub = cb$$

and

$$\alpha = \begin{vmatrix} ca & ua \\ cb & ub \end{vmatrix}$$

$$\beta = \begin{vmatrix} wa & ca \\ wb & cb \end{vmatrix}$$

where

$$\Delta = \begin{vmatrix} wa & ua \\ wb & ub \end{vmatrix}.$$

Now,

$$\bar{w} = \frac{\bar{w}}{/\bar{w}/} = \frac{\overline{skc} - \overline{smc}}{/\overline{skc} - \overline{smc}/} \simeq \frac{\overline{sk} - \overline{sm}}{/\overline{sk} - \overline{sm}/}$$

and

$$\bar{u} = \frac{\bar{u}}{/\bar{u}/} = \frac{\overline{slc} - \overline{smc}}{/\overline{slc} - \overline{smc}/} \simeq \frac{\overline{sl} - \overline{sm}}{/\overline{sl} - \overline{sm}/} .$$

Therefore, <u>in terms of the x y z coordinate system</u>, it is approximately true that

$$c = \alpha \frac{\overline{sk} - \overline{sm}}{/\overline{sk} - \overline{sm}/} + \beta \frac{\overline{sl} - \overline{sm}}{/\overline{sl} - \overline{sm}/} .$$

So a vector from the focal point to the center of the film frame is approximately:

$$\overline{cff} = \overline{sm} + \bar{c}$$

and

$$\overline{fn} = \frac{\overline{cff}}{/\overline{cff}/}$$

$$= \text{fn } 1\, \bar{e} + \text{fn } 2\, \bar{n} + \text{fn } 3\, \bar{h}.$$

See Figure 23.

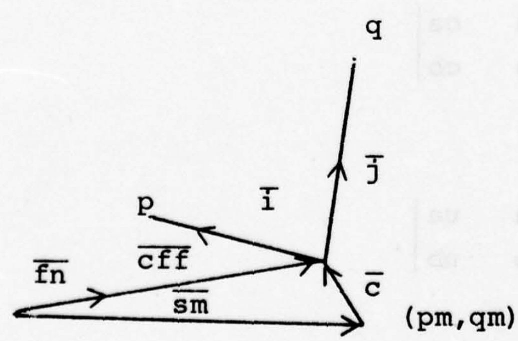


Figure 23.

Then the azimuth th and the elevation ph of the optical axis are approximately

$$th = \cos^{-1} \left[\frac{fn\ 1}{\left\{ (fn\ 1)^2 + (fn\ a)^2 \right\}^{1/2}} \right]$$

If (fn 2 < 0.0), th = -th $\qquad (-\pi \leq th \leq \pi)$

$$ph = \sin^{-1}\ (fn\ 3) \qquad \left(\frac{\pi}{2} \leq ph \leq \frac{\pi}{2} \right)$$

In order to find the approximate direction of the film frame vector $\bar{i}$ with respect to the x y z coordinate system two new unit vectors $\bar{i}'$ and $\bar{j}'$ are constructed. These lie in the film frame as do $\bar{i}$ and $\bar{j}$ and they also form with fn a right-handed trio of mutually orthogonal vectors. See Figure 24.

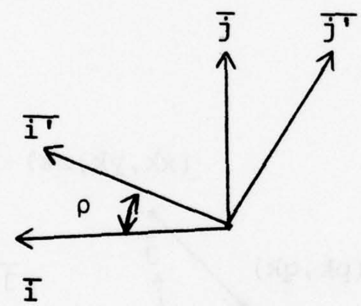


Figure 24.

In order to have a unit vector $\bar{i}'$ which will always be well defined regardless of the orientation of the camera optical axis $\overline{fn}$, $\bar{i}'$ is derived from that component of the vector joining object points k and l that lies parallel to the film frame, that is, normal to $\overline{fn}$. It will be recalled that image points k and l had the greatest separation of any point pair on the film frame. ρ is the angle to be solved for once $\bar{i}'$ and $\bar{j}'$ have been found.

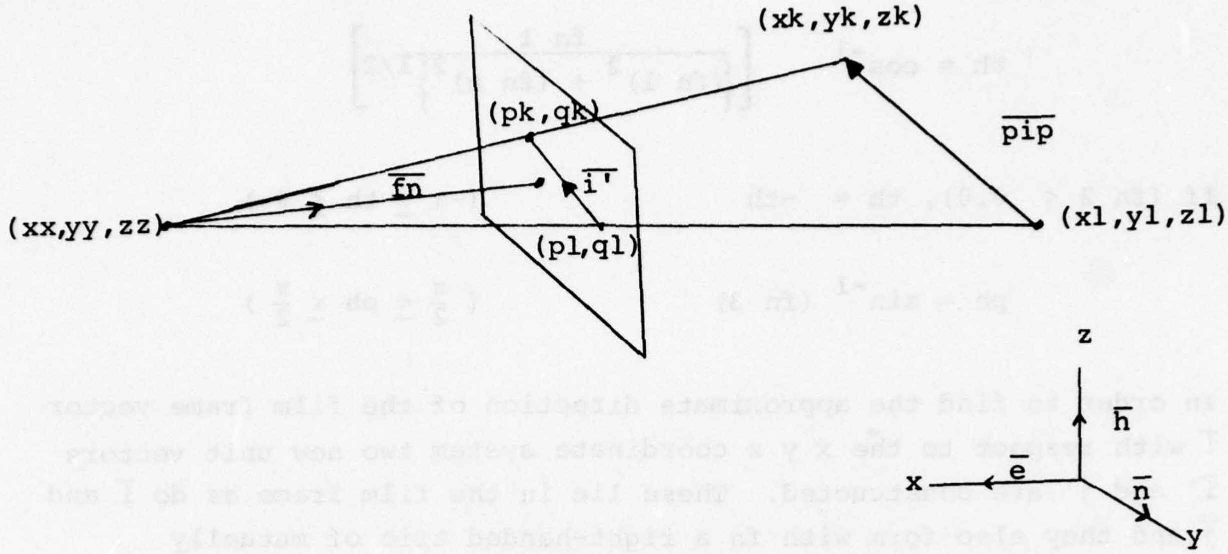


Figure 25.

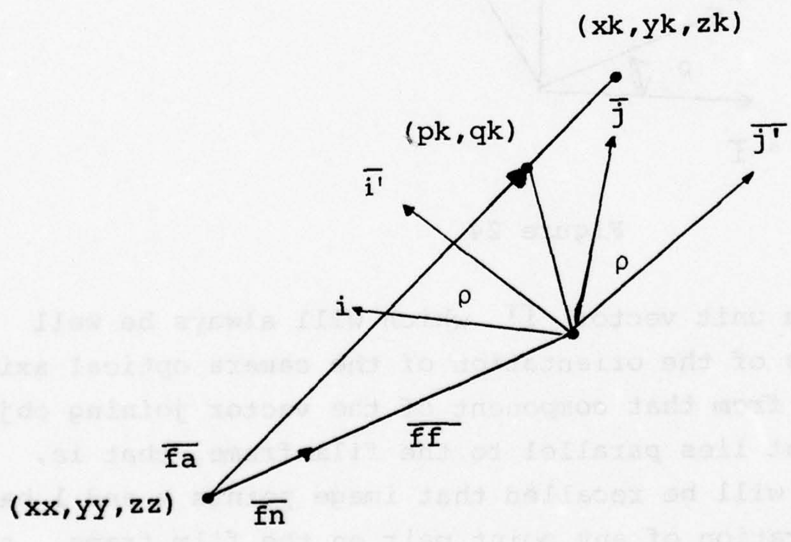


Figure 26.

Figure 25 and the following discussion give the derivation of $\overline{i'}$ and $\overline{j'}$.

$$\overline{pip} = (xk - xl)\ \overline{e} + (yk - yl)\ \overline{n} + (zk - zl)\ \overline{h}$$

$$= pipa\ \overline{e} + pipb\ \overline{n} - pipc\ \overline{h}.$$

To subtract from $\overline{pip}$ a vector parallel to $\overline{fn}$ leaving a difference vector $\overline{pi}$ normal to $\overline{fn}$ requires the solution of the following equation for the scalar a.

$$(\overline{pip} - a\ \overline{fn}\ ) \cdot \overline{fn} = 0$$

$$\overline{pip} \cdot \overline{fn} - a\ \overline{fn} \cdot \overline{fn} = 0$$

or, since $/\overline{fn}/ = (\overline{fn}.\overline{fn})^{1/2} = 1$,

$$a = \overline{pip} \cdot \overline{fn}.$$

So $\overline{pi} = \overline{pip} - \overline{pip}.\ \overline{fn}\ \overline{fn}$ is parallel to the film frame, i.e., normal to $\overline{fn}$.

$$\overline{i'} = \frac{\overline{pi}}{/\overline{pi}/}$$

$$\overline{j'} = \overline{fn} \cdot \overline{i'}.$$

To find ρ the kth image and object points are used as follows. See Figure 26.

$$\overline{r} = pk\ \overline{i} + qk\ \overline{j}$$

$$\overline{i} = \cos\rho\ \overline{i'} + \sin\rho\overline{j'}$$

$$\overline{j} = \cos\left(\rho + \frac{\pi}{2}\right)\overline{i'} + \sin\left(\rho + \frac{\pi}{2}\right)\overline{j'}$$

$$= -\sin\rho\overline{i'} + \cos\rho\overline{j'}$$

$\overline{fa}$ is a vector from the focal point to the impage point (pk, qk).

$$\overline{fa} = (ff^2 + pk^2 + qk^2)^{1/2} \frac{[(xk-xx)\ \overline{e} + (yk-yy)\overline{n} + (zk-zz)\ \overline{h}]}{[(xk-xx)^2 + (yk-yy)^2 + (zk-zz)^2]^{1/2}}$$

$$\overline{fa} = faa\ \overline{e} + fab\ \overline{n} + fac\ \overline{h}$$

$$\overline{ff} = ff\ \overline{fn} - ff\ fn1\overline{e} + ff\ fn2\overline{n} + ff\ fn3\overline{h}$$

$$= ffa\ \overline{e} + ffb\ \overline{n} + ffc\ \overline{h}$$

$$\overline{r} = \overline{fa} - \overline{ff}.$$

So $pk\ \overline{i} + qk\overline{j} = \overline{fa} - \overline{ff}$.

Substituting for $\overline{i}$ and $\overline{j}$ their expressions in $\overline{i'}$ and $\overline{j'}$ gives

$$pk \cos \rho\overline{i'} + pk \sin \rho\overline{j'} - qk \sin \rho\overline{i'} + qk \cos \rho\overline{j'} = \overline{fa} - \overline{ff}$$

$\overline{fa} - \overline{ff}$ can then be written as

$$\overline{fa} - \overline{ff} = (\overline{fa} - \overline{ff}) \cdot \overline{i'}\ \overline{i'} + (\overline{fa} - \overline{ff}) \cdot \overline{j'}\ \overline{j'}$$

Equating components of $\overline{i'}$ and $\overline{j'}$ gives the following scalar equations in which ρ is the only unknown.

$$pk \cos \rho - qk \sin \rho = (\overline{fa} - \overline{ff}) \cdot \overline{i'} = ela \text{ (defining ela)}$$

$$pk \sin \rho + qk \cos \rho = (\overline{fa} - \overline{ff}) \cdot \overline{j'} = elb \text{ (defining elb)}.$$

Solving the above equations gives ρ.

Then $\overline{i} - \cos \rho\ \overline{i'} + \sin \overline{\rho j'}$ where the components of $\overline{i'}$ and $\overline{j'}$ are known with respect to the x y z coordinate system. So we get $\overline{i} = gia\ \overline{e} + gib\ \overline{n} + gic\ \overline{h}$ where the gia, gib, gic are obtained by substituting for $\overline{i'}$ and $\overline{j'}$ their expressions in $\overline{e}$, $\overline{n}$, and $\overline{h}$. Then the azimuth thi and elevation phi of $\overline{i}$ are found as follows:

$$\text{thi} = \cos^{-1}\left[\frac{\text{gia}}{(\text{gia}^2 + \text{gib}^2)^{1/2}}\right]$$

If gib is less than 0.0, set thi = - thi.

$$\text{phi} - \sin^{-1}(\text{gic}).$$

The unit vectors $\overline{fn}$ and $\overline{i}$ obtained above complete the orientation of the camera, but they are only approximate. They depend on the values of th, ph, and ρ. The values of th, ph, and ρ found above should be very close to the correct values. To find that combination of th, ph, and ρ which best aligns all the image points we construct an error sum as follows. Due to the various errors, the point at which a ray from the focal point to an object point pierces the film frame is not identical to the image point of that object point. This is illustrated in Figure 27 for the ith image and object points.

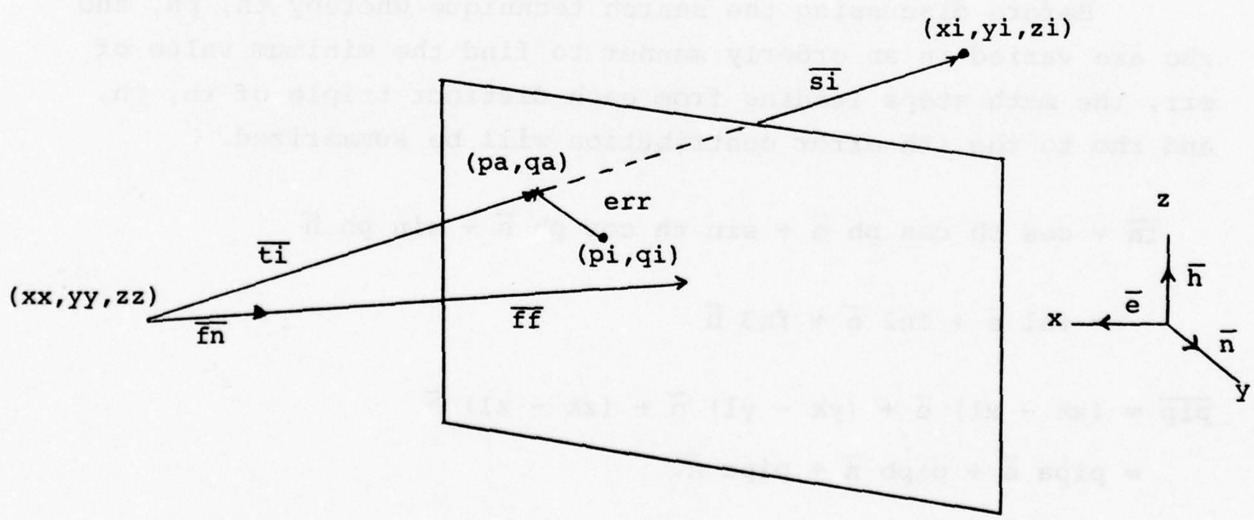


Figure 27.

Let (pa, qa) denote the film frame coordinates of the ith pierce point and erri be the distance between (pa and qa) and the ith image point at (pi, qi).

$$\text{Then erri} = [(\text{pi} - \text{pa})^2 + (\text{qi} - \text{qa})^2]^{1/2}$$

and

$$\text{err} = \sum_{i=1}^{n} \text{erri}.$$

Any change in any of the three angles th, ph, or ρ gives a new set of unit vectors $\overline{fn}$, $\overline{i}$, $\overline{j}$ and causes the coordinates of the ith pierce point (pa, qa) to change. That combination of th, ph and rho (ρ) which results in the minimum value of err is considered to be the best fit. Of course, other definitions of err are possible, the most obvious being to define err as the sum of the squares of the miss distances rather than as their sum, but it was felt that this would allow one badly read image point or badly surveyed object point to have an unduly high distorting influence on the solution.

Before discussing the search technique whereby th, ph, and rho are varied in an orderly manner to find the minimum value of err, the math steps leading from each distinct triple of th, ph, and rho to the ith error contribution will be summarized.

$$\overline{fn} = \cos \text{th} \cos \text{ph}\ \overline{e} + \sin \text{th} \cos \text{ph}\ \overline{n} + \sin \text{ph}\ \overline{h}$$

$$= \text{fn1}\ \overline{e} + \text{fn2}\ \overline{n} + \text{fn3}\ \overline{h}$$

$$\overline{pip} = (\text{xk} - \text{xl})\ \overline{e} + (\text{yk} - \text{yl})\ \overline{n} + (\text{zk} - \text{zl})\ \overline{h}$$

$$= \text{pipa}\ \overline{e} + \text{pipb}\ \overline{n} + \text{pipc}\ \overline{h}.$$

(Refer to Figure 25 and its discussion.)

$$a = \overline{pip}.\overline{fn} = pipa\ fn1 + pipb\ fn2 + pipc\ fn3$$

$$\overline{pi} = \overline{pip} - a\ \overline{fn}$$

$$= (pipa - a\ fn1)\overline{e} + (pipb - a\ fn2)\ \overline{n} + (pipc - a\ fn3)\overline{h}$$

$$= pia\ \overline{e} + pib\ \overline{n} + pic\ \overline{h}$$

$$pid = /\overline{pi}/ = (pia^2 + pib^2 + pic^2)^{1/2}$$

$$\overline{i'} = \frac{\overline{pi}}{/\overline{pi}/} = \frac{pia}{pid}\overline{e} + \frac{pib}{pid}\overline{n} + \frac{pic}{pid}\overline{h}$$

$= pia\ \overline{e} + pib\ \overline{n} + pic\ \overline{h}$ (Redefining pia, pib, pic to be components of the unit vector $\overline{i'}$.)

$$\overline{j'} = \overline{fn} \times \overline{i'}$$

$$= (fn\ 2\ pic - fn\ 3\ pib)\ \overline{e} + (fn3\ pia - fn1\ pic)\overline{n}$$

$$+ (fn1\ pib - fn2\ pia)\overline{h}$$

$$= pja\ \overline{e} + pjb\ \overline{n} + pjc\ \overline{h}.$$

From the discussion following Figure 26,

$$\overline{i} = \cos\rho\ \overline{i'} + \sin\rho\ \overline{j'}.$$

Inserting the equation $\overline{i'}$ and $\overline{j'}$ and grouping $\overline{e}$, $\overline{n}$, and $\overline{h}$

$$i = (pia\cos\rho + pja\sin\rho)\ \overline{e} + (pib\cos\rho + pjb\sin\rho)\overline{n}$$

$$+ (pic\cos\rho + pjc\sin\rho)\overline{h}$$

$$= tia\ \overline{e} + tib\ \overline{n} + tic\ \overline{h}.$$

Similarly, $\overline{j} = -\sin\rho\ \overline{i'} + \cos\rho\overline{j'}$

$$= (-pia,\ \sin\rho + \cos\rho)\overline{e} + (-pib\sin\rho + pjb\cos\rho)\overline{n}$$

$$+ (-pic\sin\rho + pjc\cos\rho)\overline{h}$$

$$= tja\ \overline{e} + tjb\ \overline{n} + tjc\ \overline{h}$$

Referring now to Figure 27,

$\overline{ti}$ is the vector locating the pierce point (pa, qa) due to the ith object point. $\overline{ti}$ is a scalar multiple of $\overline{si}$ $\overline{ti} = w\ \overline{si}$ where w is unknown.

The projection of $\overline{ti}$ on $\overline{fn}$ must equal the focal length ff.

$$\overline{ti}.\overline{fn} = ff$$

or

$$w\ \overline{si}.\overline{fn} = ff.$$

So

$$w = \frac{ff}{\overline{si}.\overline{fn}} .$$

In component form

$$\overline{si} = (xi - xx)\ \bar{e} + (yi - yy)\ \bar{n} + (zi - zz)\bar{h}$$

and

$$w = \frac{ff}{(xi - xx)\ fn1 + (yi - yy)\ fn2 + (zi - zz)\ fn3} .$$

A vector $\bar{r}$ from the center of the film frame to the pierce point is gotten from the equation

$$\bar{r} = \overline{ti} - ff\ \overline{fn}.$$

See Figure 28.

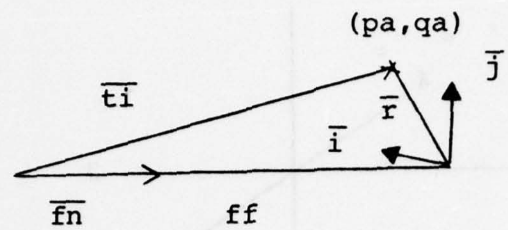


Figure 28.

In component form:

$$\overline{r} = (w\ (xi - xx) - ff\ fn1)\overline{e} + (w\ (yi - yy) - ff\ fn2)\overline{n}$$

$$+ (w\ (zi - zz) - ff\ fn3)\overline{h}$$

$$= ra\ \overline{e} + rb\ \overline{n} + rc\ \overline{h}.$$

Now since $\overline{r}$ lies entirely in the film plane, it may be represented in terms of $\overline{i}$ and $\overline{j}$ components as follows:

$$\overline{r} = \overline{r}\ .\ \overline{i}\ \overline{i} + \overline{r}\ .\ \overline{jj}$$

$$= pa\ \overline{i} + qa\ \overline{j}.$$

Explicitly,

$$pa = \overline{r}\ .\ \overline{i} = ra\ tia + rb\ tib + rc\ tic$$

$$qa = \overline{r}\ .\ \overline{j} = ra\ tja + rb\ tjb + rc\ tjc$$

Let $\overline{ri} = pi\ \overline{i} + qi\ \overline{j}$

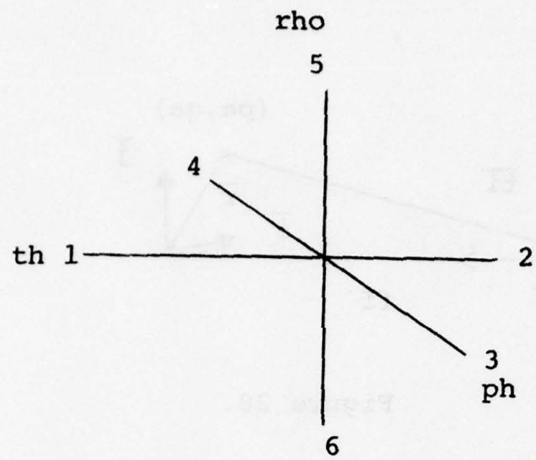


Figure 29.

Then

$$erri = /\overline{ri} - \overline{r}/$$

$$= [(pi - pa)^2 + (qi - qa)^2]^{1/2} .$$

Then

$$err = \sum_{i=1}^{m} erri.$$

The scheme whereby th, ph, and rho are varied to minimize err is indicated in Figure 29.

The points numbered 1 through 6 indicate the order in which th, ph, and rho are varied. If point 1 (indicating a positive increment added to the present value of th) gives a lower err than exists at the origin, then successive increments are added to th so long as the value of err continues to fall. Points 1, 3, and 5 correspond to increases in th, ph, and rho respectively and 2, 4, and 6 to decreases. Although the axes in Figure 24 serve merely to indicate the order of variation, the procedure is precisely the same as that used to minimize err (fr, xx, ys,zs).

See Figure 18.

When err (th, ph, rho) has been minimized, the final values of $\overline{fn}$, $\bar{i}$, and $\bar{j}$ are computed. Also computed are the azimuth and elevation of the vector $\bar{i}$, thi ,and phi respectively.

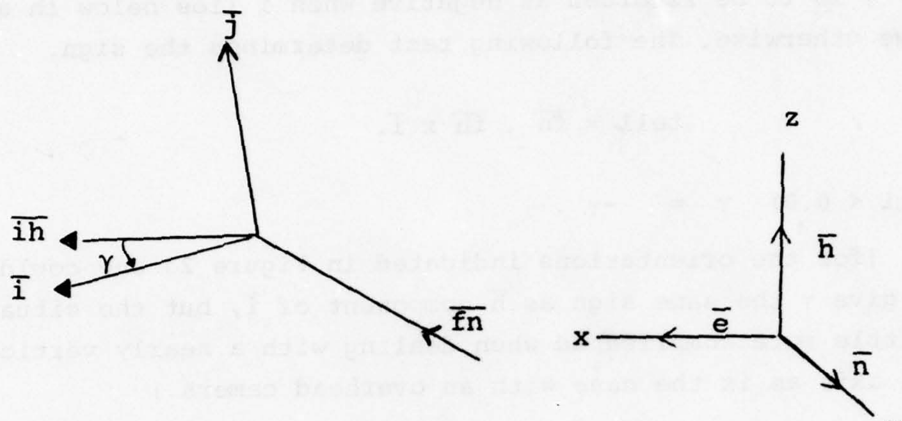


Figure 30.

At this point the camera has been located, oriented, and its focal length determined. The only one of the seven unknowns not yet solved for is the tilt angle, γ, of the camera from the horizontal about its optical axis. Knowing the azimuth thi and the elevation phi of the unit vector $\bar{i}$ makes (gam) redundant, but it is among the output of the program, so its derivation will be given.

See Figure 30.

$\overline{ih}$ is a unit vector in the film frame which is parallel to the x y plane (i.e., horizontal) of the main coordinate system.

$$\overline{ih} = \frac{\bar{h} \times \overline{fn}}{/\bar{h} \times \overline{fn}/}$$

By definition of the cross product $\overline{ih}$ is normal to both $\overline{fn}$ and $\bar{h}$. Therefore, it both lies in the film frame and is parallel to the xy plane. It is obviously a unit vector.

$$\gamma = \cos^{-1} (\overline{ih} . \overline{h})$$

γ is to be recorded as negative when $\overline{i}$ lies below $\overline{ih}$ and positive otherwise. The following test determines the sign.

$$\text{tell} = \overline{fn} . \overline{ih} \times \overline{i}.$$

If (tell < 0.0) $\gamma = -\gamma$.

(for the orientations indicated in Figure 25 one could simply give γ the same sign as $\overline{h}$ component of $\overline{i}$, but the situation is a little more complicated when dealing with a nearly vertical optical axis as is the case with an overhead camera.)

The solution is complete. To give a measure of how good the whole situation is, the following check was devised. See Figure 31.

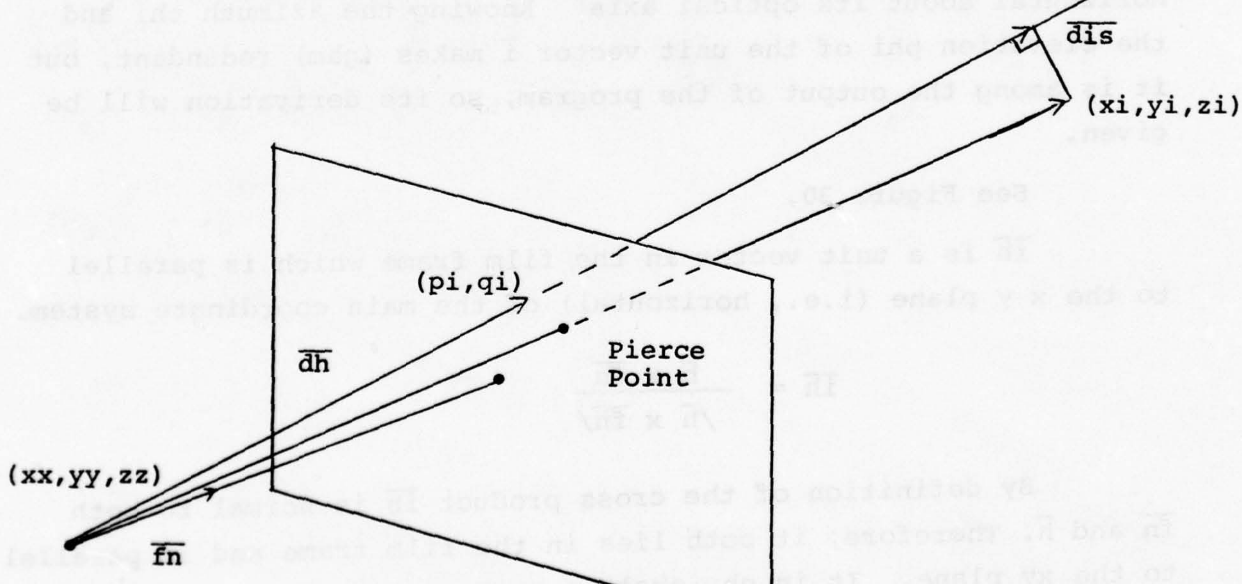


Figure 31.

A ray is extended from the camera focal point through each image point (pi, qi) past its corresponding object point and the distance vector $\overline{dis}$ of the ray's nearest approach to the object point is computed. If all distances $\overline{dis}$ so computed are of small magnitude, the fit is obviously good.

$$\overline{dh} = ff\ \overline{fn} + pi\ \overline{i} + qi\ \overline{j}$$

$$= dha\ \overline{e} + dhb\ \overline{n} + dhc\ \overline{h}$$

where the final form is obtained by expressing $\overline{fn}$, $\overline{i}$, and $\overline{j}$ in terms of their components in the principal coordinate system and then grouping on the principal coordinate system unit vectors $\overline{e}$, $\overline{n}$, and $\overline{h}$.

$$\overline{sh} = (xi - xx)\ \overline{e} + (yi - yy)\ \overline{n} + (zi - zz)\overline{h}$$

$$= sha\ \overline{e} + shb\ \overline{n} + shc\ \overline{h}$$

$$dh = \frac{\overline{dh}}{/\overline{dh}/}$$ (a unit vector in the director of the ith image point (pi,qi).)

There is a scalar coefficient, acof, such that

$$acof\ \overline{dh} = \overline{sh} + \overline{dis}.$$

Dotting through by $\overline{dh}$

$$acof\ \overline{dh}\ .\ \overline{dh} = \overline{sh}\ .\ \overline{dh} + \overline{dis}.\ \ \overline{dh}$$

$$= \overline{sh}\ .\ \overline{dh}$$ (since $\overline{dis}$ is perpendicular to $\overline{dh}$)

$$acof = \overline{sh}\ .\ \overline{dh} \text{ since } \overline{dh}\ .\ \overline{dh} = 1.$$

So, $\overline{dis} = acof\ \overline{dh} - \overline{sh}$ and the miss distance is dis where dis = $/\overline{dis}/$.

These miss distances have characteristically fallen into a range of 0.05-inches to 0.22-inches in the solutions run thus far. Good agreement in this check indicates not only that the camera data found is correct, but also that the survey of the object points and the reading of the image points were probably both quite accurate. In closing the discussion of the mathematics used, it should be mentioned that one or two grossly inaccurate image or object point locations can completely swamp out the relative minimum indicated in Figure 15.

3.1.2 Program POOCH

A brief discussion of the overall program operation will be given before going into input and output in detail. A reduced-size-copy of the program is included in Appendix E. Figure 32 contains a block diagram of the program.

The main program POOCH reads in and scales the data. Subroutine FIND together with its auxiliary subroutines, HORSY, REFIN, and ANGLE, computes the correct values of focal point position (xx, yy, zz) and focal length ff. FIND calls HORSY twice to locate points P and Q (shown in Figures 14 and 17). HORSY performs the 27 point cube search displayed in Figure 16. Subroutine ANGLE computes the value of err for any focal length fs and focal point location (sx, ys, zs). After points P and Q (see Figures 14 and 17) have been found, FIND uses subroutine REFIN to find the best values of focal length ff and focal point location (xx, yy,zz). REFIN performs the six point search illustrated in Figure 29. Both HORSY and REFIN use ANGLE to compute err (fx, xs, ys, zs).

Program POOCH then calls subroutine SERCH which provides approximate values of the camera orientation variables th, ph, and rho. Finally, subroutine DANG is called to optimize the approximate camera orientation produced by SERCH. DANG's auxiliary subroutine WRANG computes an error value which is the sum of the distances of all pierce points from their corresponding image points.

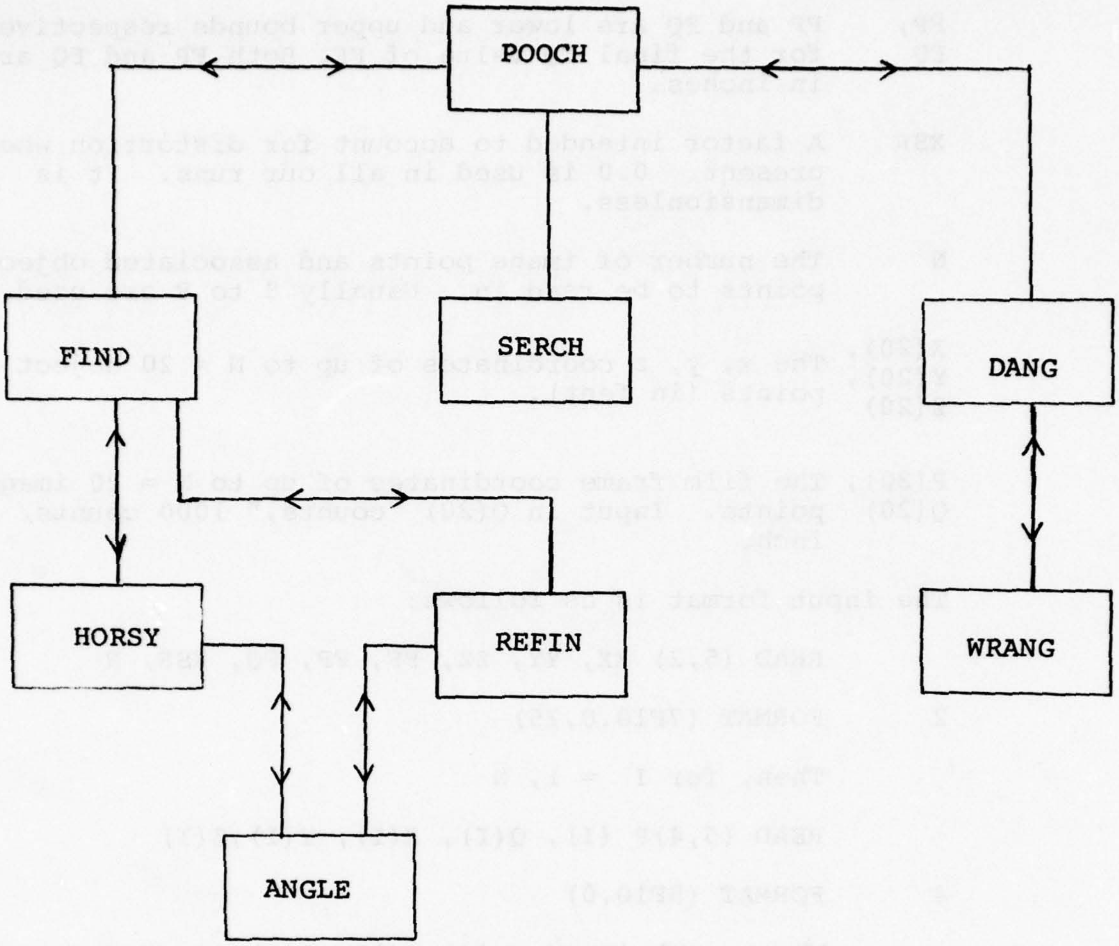


Figure 32. Block Diagram of Program POOCH.

See Figures 27 and 28 and the associated discussion.

The following list contains the variables which must be input to the program:

XX	The x, y, and z coordinates of the estimated camera position.
YY	Input in feet.
ZZ	
FF	The nominal focal length of the camera in inches times the magnification of the film frame reader used.

FP, FQ	FP and FQ are lower and upper bounds respectively for the final FQ value of FF. Both FP and FQ are in inches.
XSR	A factor intended to account for distortion when present. 0.0 is used in all our runs. It is dimensionless.
N	The number of image points and associated object points to be read in. Usually 5 to 8 are used.
X(20), Y(20), Z(20)	The x, y, z coordinates of up to N = 20 object points (in feet).
P(20), Q(20)	The film frame coordinates of up to N = 20 image points. Input in Q(20) "counts," 1000 counts/inch.

The input format is as follows:

```
      READ (5,2) XX, YY, ZZ, FF, FP, FQ, XSR, N
2     FORMAT (7F10.0,I5)
      Then, for I  = 1, N
      READ (5,4)P (I), Q(I), X(I), Y(I),Z(I)
4     FØRMAT (5F10.0)
```

Where each image point P(I), Q(I) is on the same card as its associated object point X(I), Y(I), Z(I).

Multiple cases may be read into the program. Figure 33 shows a sample data deck for a case run.

There is at present a great deal of working output taken from the program but most of it was used for debug purposes and is of little consequence now and can be eliminated. Rather than waste many pages describing this debug output, that part of the output giving the camera location and orientation and the various checks on the goodness of the solution will be discussed.

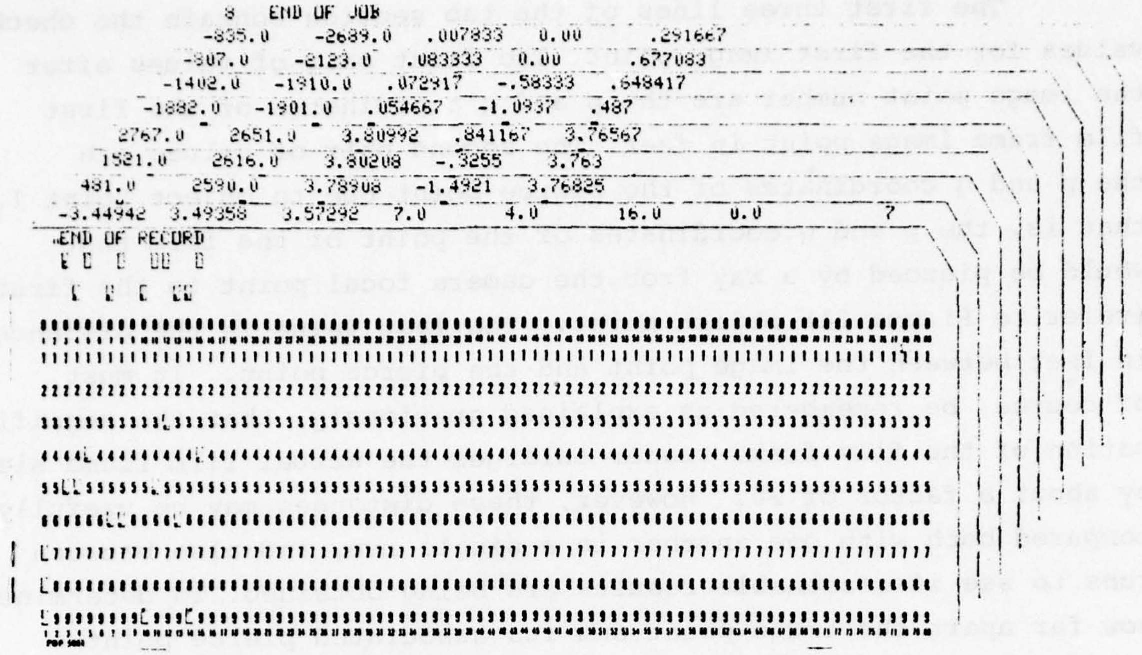


Figure 33. Sample Data Input to Program POOCH.

Figure 34 shows a reduced-size section of the tab containing the important output.

```
DANG  .644895E+00 -.290751E+00 -.236822E+01  .429285E-02  .300000E-04 -.100000E+01   2
DANG  .644895E+00 -.290781E+00 -.236822E+01  .429495E-02  .300000E-04 -.100000E+01   2
DANG  .644895E+00 -.290751E+00 -.236819E+01  .428149E-02  .300000E-04  .100000E+01   3
DANG  .644895E+00 -.290751E+00 -.236816E+01  .427080E-02  .300000E-04  .100000E+01   3
DANG  .644895E+00 -.290751E+00 -.236813E+01  .426089E-02  .300000E-04  .100000E+01   3
DANG  .644895E+00 -.290751E+00 -.236810E+01  .425169E-02  .300000E-04  .100000E+01   3
DANG  .644895E+00 -.290751E+00 -.236807E+01  .424338E-02  .300000E-04  .100000E+01   3
DANG  .644895E+00 -.290751E+00 -.236804E+01  .423594E-02  .300000E-04  .100000E+01   3
DANG  .644895E+00 -.290751E+00 -.236801E+01  .422939E-02  .300000E-04  .100000E+01   3
DANG  .644895E+00 -.290751E+00 -.236798E+01  .422373E-02  .300000E-04  .100000E+01   3
DANG  .644895E+00 -.290751E+00 -.236795E+01  .421891E-02  .300000E-04  .100000E+01   3
DANG  .644895E+00 -.290751E+00 -.236792E+01  .421490E-02  .300000E-04  .100000E+01   3
DANG  .644895E+00 -.290751E+00 -.236789E+01  .421164E-02  .300000E-04  .100000E+01   3
READ PT. PIERCE PT.,ERROR    1 -.400833E-01  .215833E+00 -.395739E-01  .216441E+00  .793244E-03
ITH OBJECT POINT AND DISTANCE VECTOR
  1  .378908E+01  .149210E+01  .376825E+01  .361385E-02 -.516660E-02 -.712783E-02 .951632E-02
READ PT. PIERCE PT.,ERROR    2 -.126750E+00  .218000E+00 -.126736E+00  .217987E+00  .186950E-04
ITH OBJECT POINT AND DISTANCE VECTOR
  2  .380208E+01  .325500E+00  .376300E+01  .619822E-04 -.131612E-03  .134775E-03 .197915E-03
READ PT. PIERCE PT.,ERROR    3 -.230583E+00  .220917E+00 -.230635E+00  .220655E+00  .267077E-03
ITH OBJECT POINT AND DISTANCE VECTOR
  3  .380992E+01 -.841167E+00  .376567E+01 -.294285E-03  .665930E-03  .256087E-02 .266235E-02
READ PT. PIERCE PT.,ERROR    4  .156833E+00 -.158417E+00  .156881E+00 -.158629E+00  .217765E-03
ITH OBJECT POINT AND DISTANCE VECTOR
  4  .546670E-01  .109370E+01  .487000E+00  .987714E-03  .348796E-03  .157745E-02 .189211E-02
READ PT. PIERCE PT.,ERROR    5  .116833E+00 -.159167E+00  .116832E+00 -.159100E+00  .663036E-04
ITH OBJECT POINT AND DISTANCE VECTOR
  5  .729170E-01  .583330E+00  .648417E+00 -.214034E-03 -.171378E-03 -.477003E-03 .550193E-03
READ PT. PIERCE PT.,ERROR    6  .672500E-01 -.176917E+00  .652500E-01 -.177516E+00  .208735E-02
ITH OBJECT POINT AND DISTANCE VECTOR
  6  .833330E-01-0.               .677083E+00 -.870255E-02  .134546E-01  .488198E-02 .167549E-01
READ PT. PIERCE PT.,ERROR    7  .695833E-01 -.224083E+00  .699013E-01 -.223508E+00  .657594E-03
ITH OBJECT POINT AND DISTANCE VECTOR
  7  .783300E-02-0.               .291667E+00 -.264507E-03 -.353976E-02 -.378272E-02 .518737E-02
X,Y,Z,F,AZ,EL,TILT -.330763E+01 -.326210E+01  .357316E+01  .666667E+00  .644790E+00 -.290829E+00 -.236778E+01
ERROR@ITER.  .410803E-02  137
DANG,THI,PHI,TILT  .221372E+01  .624950E-02  .652351E-02
NORMAL COMPLETION
```

Figure 34. Sample Data Output from Program POOCH.

The first three lines of the tab section contain the check values for the first image point. The first pair of values after the image point number are the p and q coordinates of the first film frame image point in feet. The second pair of values are the p and q coordinates of the pierce point due to object point 1, that is, the p and q coordinates of the point of the film that would be pierced by a ray from the camera focal point to the first (refer to Figure 31) object point. The last value is the distance in feet between the image point and the pierce point. It must, of course, be remembered as explained previously, that the magnification of the film frame reader enlarges the actual film frame size by about a factor of 20. However, these distances may be usefully compared both with one another in a single run, and also between runs to see if reasonable results are being obtained. To determine how far apart the image point and its associated pierce point are on the real film frame, the distance given could be divided by about 20.4, the approximate magnification of the reader used.

The last line of output for the first image and object points gives the object point number, then the x, y, and z coordinates in feet of the object point. The fifth, sixth, and seventh values are the x, y, and z components, respectively, of the miss vector $\overline{dis}$ described in Figure 31 and the text pertaining thereto. Its components are given in feet. The last value is the magnitude of $\overline{dis}$ in feet. This is the most important value for judging how good the solution is. The numbers written into the right of these values are the magnitude of $\overline{dis}$ in <u>inches</u>, and as can be seen, are quite reasonable. This assures that not only did the program provide a good solution, but also that the object points were correctly surveyed and their film frame images were correctly read. In short, when the magnitudes of $\overline{dis}$ are small for each object point, it provides a comprehensive check on the entire data reduction scheme.

In the run illustrated, there were seven points available on which to base the solution. Immediately after the listing of the above data for the last of these points, the camera solution data is output. In the line beginning X, Y, Z, F ... the first three numerical values are the x, y, and z coordinates of the location of the camera focal point (in feet). The fourth value is the fictitious program focal length, i.e., it is the product of the true camera focal length and the film reader magnification and is given in feet. The fifth and sixth values are the azimuth and elevation angles of the camera optical axis, both given in radians. The last value in this line of output is the angle that has been referred to us as rho. It is of no consequence after the camera solution has been generated.

The line beginning DAMG,.. gives the azimuth and elevation angles of the film frame $\bar{I}$ axis and the tilt angle of the camera from horizontal about the optical axis in that order. All angles are in radians.

It yet remains to explain a minor point regarding coordinate systems. The experimental coordinate system is a left hand system. See Figure 35.

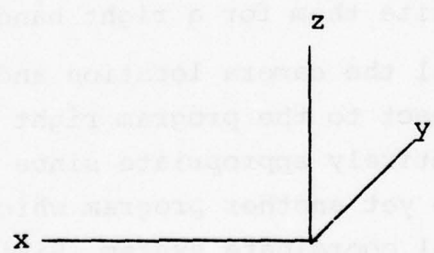


Figure 35.

The input coordinates of all object points (xi, yi, zi) and the estaimated initial camera position (xx, yy, zz) are input with respect to this coordinate system. The program changes the sign of the y coordinate of each of these points so that they are properly represented for the right hand coordinate system used in the program. See Figure 36.

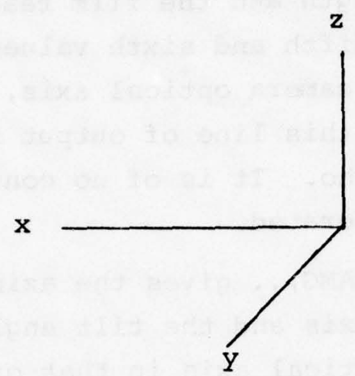


Figure 36.

This change was made so that it would not be necessary to define the components of every vector cross product used for a left hand coordinate system when it is second nature to most to automatically write them for a right handed system.

Moreover all the camera location and orientation data is output with respect to the program right hand coordinate system. This is entirely appropriate since the camera solution is used as input to yet another program which also contains a right hand principal coordinate system. Similarly, the coordinates of the object points are also output with respect to the program right hand system rather than with respect to the original experimental left hand system.

The film frame reader has a coordinate system as indicated in Figure 37 with the horizontal axis positive to the right.

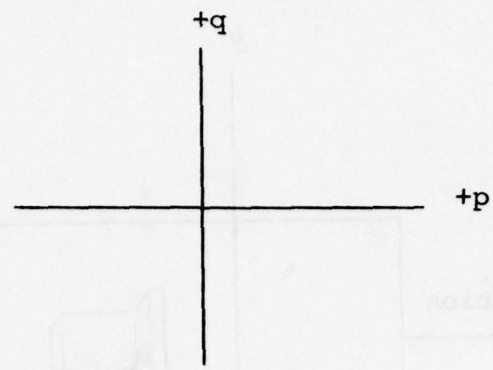


Figure 37.

In order that the unit vectors $\overline{fn}$, $\overline{i}$, $\overline{j}$ (refer to Figure 12) in that order form a right hand system, the sign of the horizontal coordinate of each image point is changed. Moreover the film frame coordinates are output with the signs of their horizontal coordinates still reversed.

There is nothing very involved about these sign changes, but one should be aware of what has been done if he attempts to use the program. These sign changes are clearer from the tab of program POOCH than from all the explanation above, and could be easily changed to suit if one were going to use the program for an experiment in which the experimental coordinate system itself were right handed.

3.2 TWO-RAY SOLUTIONS OF COORDINATES OF POINTS

The Camera Location Program has direct application in Program Sled which performs the reduction of data taken during seat harness tests. A dummy and an animal, or two dummies, are strapped into seats mounted aboard an acceleration sled. Also rigidly mounted aboard the sled are two high-speed cameras which photograph the reactions of the test subjects as the sled accelerates down its track in the +x direction. See Figure 38.

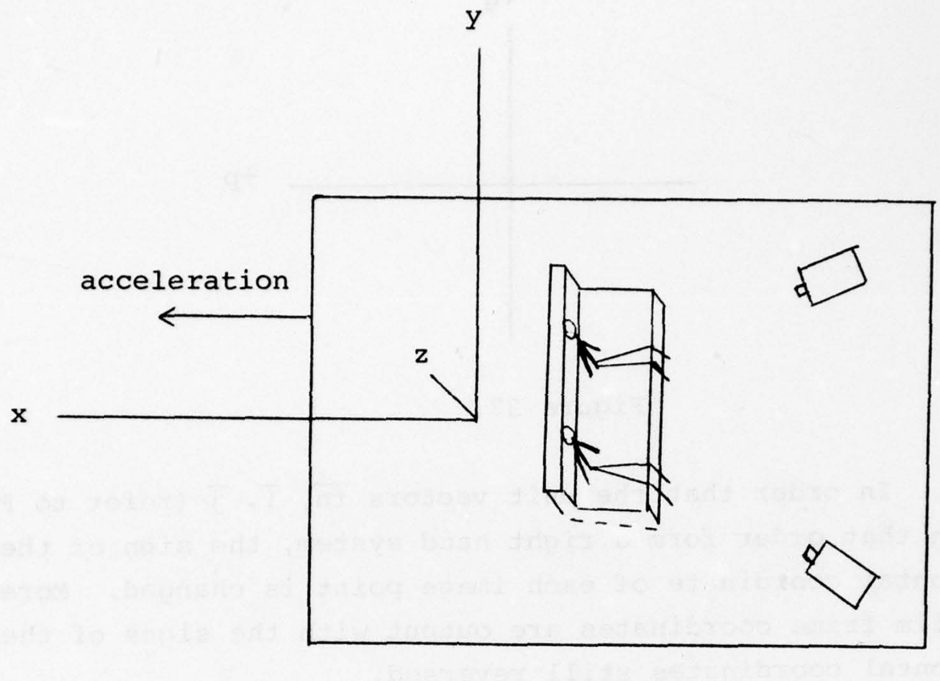


Figure 38.

The experimental coordinate system is a left-hand x y z system affixed to the moving sled. All subject motion recorded is understood to be relative to the sled. In cases run so far, two targets (plastic disks marked so as to be easily discerned on the film frame reader) are attached to each test subject. For a dummy, the forehead and chin have been targeted. When the subject was an animal,head accelerometer pack and tip of the snout were chosen as target points. The whole purpose of program Sled is to provide displacement versus time graphs of each of the targeted points on each of the test subjects.

The camera location program is used first to accurately locate and orient each of the two cameras. The coordinates of a number of points rigidly affixed to the sled are accurately measured. Their film frame image coordinates are determined for each camera. The camera location and orientation data obtained from the camera location program is then input to the Sled program.

The principal coordinate system in the Sled program is a right hand x y z system, not the experimental left-hand system indicated in Figure 38. This change is accomplished simply by changing the sign of the y coordinate of every point after it has been input to Sled. Also, so that the camera system axes will constitute a right-hand coordinate system, the horizontal film frame coordinate is reversed in sign. Unit vectors $\overline{e}$, $\overline{n}$, and $\overline{h}$ are directed along the x, y, z axes respectively. See Figure 39. The x, y, and z axes are mutually perpendicular.

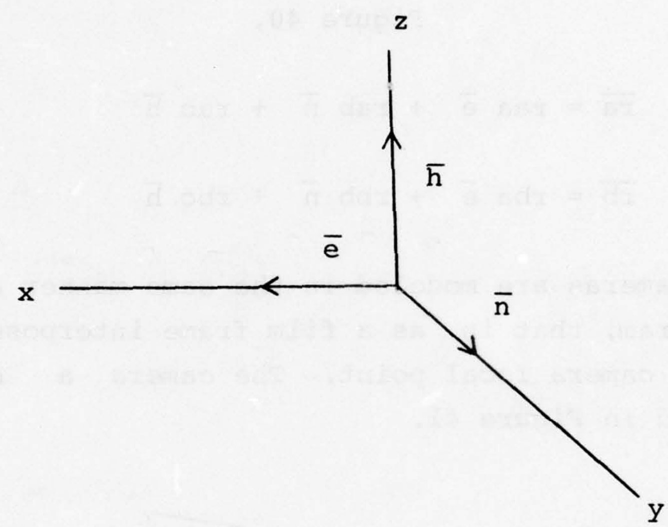


Figure 39.

The two cameras are designated camera a and camera b and their focal points are located by vectors $\overline{ra}$ and $\overline{rb}$ respectively. See Figure 40.

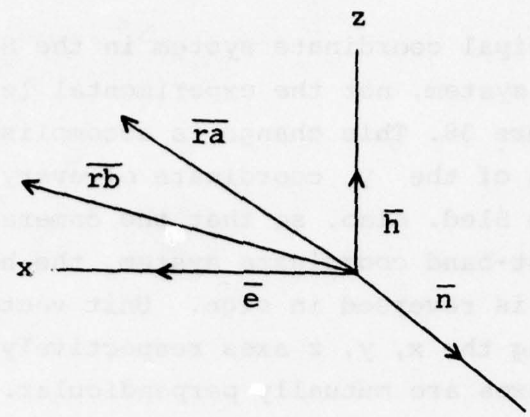


Figure 40.

$$\overline{ra} = raa\ \bar{e} + rab\ \bar{n} + rac\ \bar{h}$$

$$\overline{rb} = rba\ \bar{e} + rbb\ \bar{n} + rbc\ \bar{h}$$

The cameras are modeled in the same manner as in the camera location program, that is, as a film frame interposed between the scene and the camera focal point. The camera a coordinate system is illustrated in Figure 41.

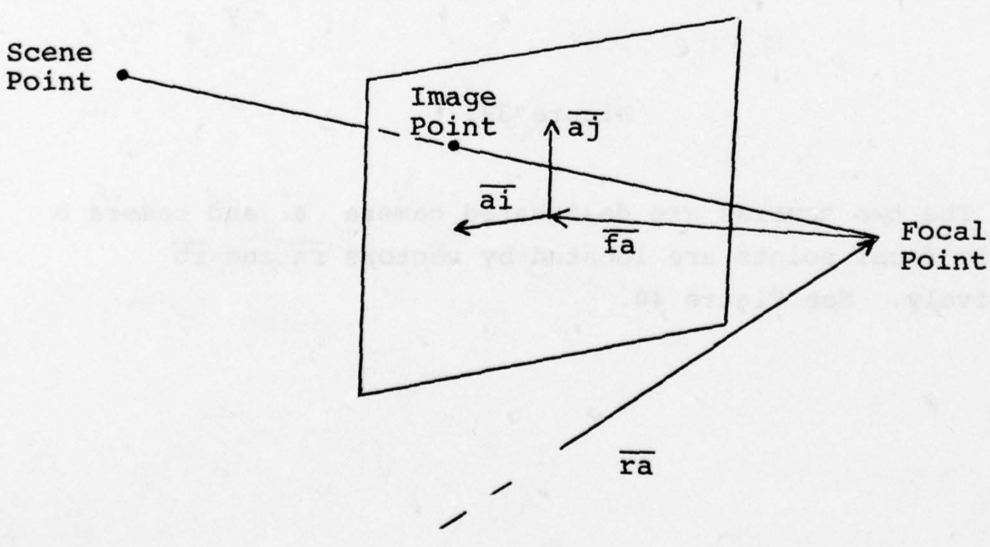


Figure 41.

$\overline{fa}$ lies along the camera optical axis and is perpendicular to the horizontal and vertical film frame unit vectors $\overline{ai}$ and $\overline{aj}$. The magnitude of $\overline{fa}$ is fa, the camera a focal length. (As in the camera location program, $\overline{fa}$ is actually the product of the true camera focal length and the film reader magnification. The analogous vectors for camera b are $\overline{bi}$, $\overline{bj}$, $\overline{fb}$.

The data that must be supplied to completely define camera a consists of the three components of its position vector, raa, rab, rac, the azimuth, elevation, and magnitude of $\overline{fa}$ which are tha, pha, fa, the azimuth and elevation of $\overline{ai}$ which are thia, phia. For camera b the analogous quantities are in the same order: rba, rbb, rbc, fb, thb, phb, thib, phib.

We will now discuss the principal parts of the analysis in the various subroutines. The first topic will be the derivation of the α camera ray solution. See Figure 42.

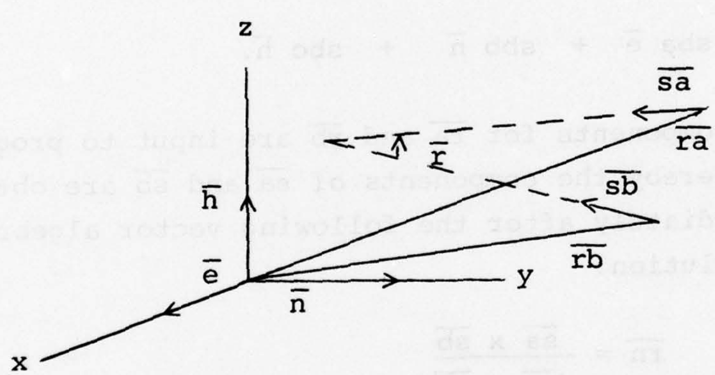


Figure 42.

$\overline{ra}$ and $\overline{rb}$ are the position vectors locating cameras a and b respectively. $\overline{sa}$ and $\overline{sb}$ are unit vectors along the ray direction from the camera focal point toward the film frame image of one of the moving points on a dummy, a point whose position is to be determined with respect to the x, y, z coordinate

system. Due to film frame reading errors, camera location and orientation errors, and also to the interpolation used to find $\overline{sa}$ and $\overline{sb}$ at the same instant in time, the rays will not in general intersect, but will miss each other by a small distance denoted by the vector $\overline{r}$. $\overline{r}$ is necessarily perpendicular to both rays.

The position of the moving point on the dummy is assumed to lie at the midpoint of $\overline{r}$. $\overline{ra}$, $\overline{rb}$, $\overline{sa}$, and $\overline{sb}$ are known completely. Although the vector algebra solution below does not explicitly use the names of the components of these vectors, we will list them for completeness sake:

$$\overline{ra} = raa\ \overline{e} + rab\ \overline{n} + rac\ \overline{h}$$

$$\overline{rb} = rba\ \overline{e} + rbb\ \overline{n} + rbc\ \overline{h}$$

$$\overline{sa} = saa\ \overline{e} + sab\ \overline{n} + sac\ \overline{h}$$

$$\overline{sb} = sba\ \overline{e} + sbb\ \overline{n} + sbc\ \overline{h}.$$

The components for $\overline{ra}$ and $\overline{rb}$ are input to program SLED. The method whereby the components of $\overline{sa}$ and $\overline{sb}$ are obtained is taken up immediately after the following vector algebra two ray solution. Solution:

$$\overline{rn} = \frac{\overline{sa} \times \overline{sb}}{/\overline{sa} \times \overline{sb}/}$$

is a unit vector collinear with $\overline{r}$, that is, $\overline{r}$ is perpendicular to both $\overline{sa}$ and $\overline{sb}$.

Let $\overline{r} = d\ \overline{rn}$ where d is the as-yet-unknown-scalar multiple of $\overline{rn}$ which yields $\overline{r}$. (d will be negative if the $\overline{sb}$ ray passes over the $\overline{sa}$ ray in a particular case.)

(1) $\overline{ra} + coa\ \overline{sa} = \overline{rb} + cob\ \overline{sb} + \overline{r}$ where coa and cob are scale factors to be solved for.

Substituting for $\overline{r}$ gives

(2) $\overline{ra} + coa\ \overline{sa} = \overline{rb} + cob\ \overline{sb} + d\ \overline{rn}$.

Dotting through by $\overline{rn}$ gives

$$\overline{ra} \cdot \overline{rn} + coa\ \overline{sa} \cdot \overline{rn} = \overline{rb} \cdot \overline{rn} + cob\ \overline{sb} \cdot \overline{rn} + d\ \overline{rn} \cdot \overline{rn}$$

$$\overline{ra} \cdot \overline{rn} - \overline{rb} \cdot \overline{rn} = d.$$

(3) or $d = (\overline{ra} - \overline{rb}) \cdot \overline{rn}$

Rewriting (2) in an altered form gives:

(4) $coa\ \overline{sa} - cob\ \overline{sb} = \overline{rb} - \overline{ra} + d\ \overline{rn}$.

Dotting through (4) by $\overline{sa}$ gives:

$$coa - cob\ \overline{sb} \cdot \overline{sa} = (\overline{rb} - \overline{ra})\ \overline{sa}$$

or (5) $coa = (\overline{rb} - \overline{ra}) \cdot \overline{sa} + cob\ \overline{sa} \cdot \overline{sb}$

Dotting through (4) by sb gives:

(6) $coa\ \overline{sa} \cdot \overline{sb} - cob = (\overline{rb} - \overline{ra}) \cdot \overline{sb}$.

Substituting (5) for coa in (6) gives

$$[(\overline{rb} - \overline{rn}) \cdot \overline{sa} + cob\ \overline{sa} \cdot sb\ \overline{sa}] \cdot \overline{sb} - cob = (\overline{rb} - \overline{ra}) \cdot \overline{sb}.$$

Solving for cob gives:

$$(7) \quad cob = \frac{(\overline{rb} - \overline{ra}) \cdot \overline{sa}\ \overline{sa} \cdot \overline{sb} - (\overline{rb} - \overline{ra}) \cdot \overline{sb}}{1 - (\overline{sa} \cdot \overline{sb})^2}$$

Substituting the value of cob into (5) gives coa.

A vector $\overline{sol}$ locating the solution point (midpoint of $\overline{r}$) can be computed by either of two equivalent vector sums.

$$\overline{sol} = \overline{rb} + cob\ \overline{sb} + 0.5\ \overline{r} \quad \text{(see Figure 9)}$$

or $$\overline{sol} = \overline{ra} + coa\ \overline{sa} = 0.5\ \overline{r}.$$

The ray miss distance dis is gotten from dis = /d/. d in the equation below

$$\overline{r} = d\ \overline{rn}$$

will be negative if $\overline{rn}$ should have a direction or sense opposite to $\overline{r}$. Its sign depends on the order in which the cameras were read in and which ray is uppermost.

The above solution is performed in subroutine SOLVE. In order that the unit vectors $\overline{sa}$ and $\overline{sb}$ have their components computed with respect to the main coordinate system, the components of each camera coordinate system vector must be known with respect to the main coordinate system. Let (pa, qa) be the film frame coordinates of camera a, fa, its focal length, tha and pha the azimuth and elevation of its optical axis, thia and phia the azimuth and elevation of the camera a $\overline{sa}$ film frame unit vector. See Figure 43.

Now $\overline{ra} = raa\ \overline{e} + rab\ \overline{n} + rac\ \overline{h}$ is known, its components being read in.

$$\overline{fa} = fa \cos tha \cos pha\ \overline{e} + fa \sin tha \cos pha\ \overline{n}$$
$$+ \overline{fa} \sin pha\ \overline{h} = faa\ \overline{e} + fab\ \overline{n} + fac\ \overline{h}$$

$$ai = \cos thia \cos phia\ \overline{e} + \sin thia \cos phia\ \overline{n}$$
$$+ \sin phia\ \overline{h} = aia\ \overline{e} + aib\ \overline{n} + aic\ \overline{h}$$

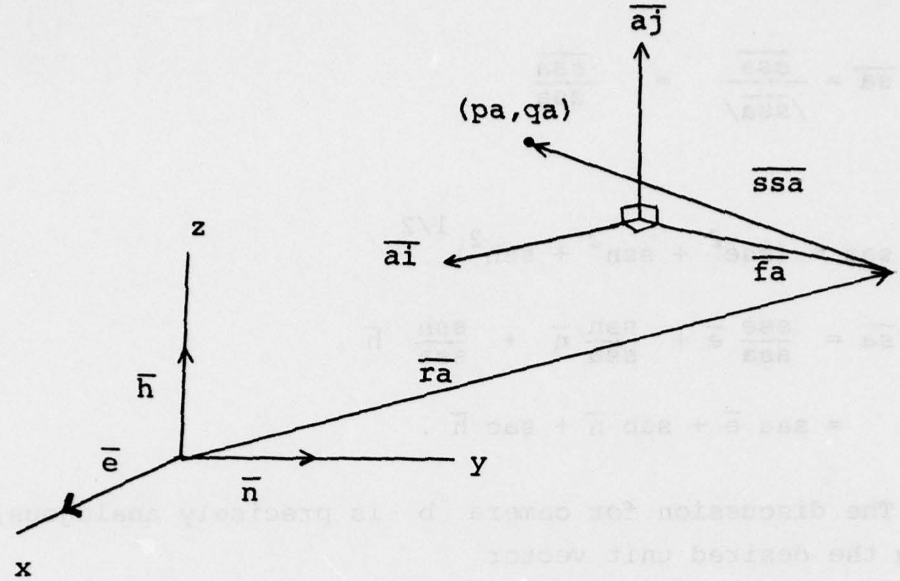


Figure 43.

$$\overline{aj} = \frac{\overline{fa} \times \overline{ai}}{fa}$$

$$= \frac{fab\ aic - fac\ aib}{fa}\bar{e} + \frac{fac\ aia - faa\ aic}{fa}\bar{n}$$

$$+ \frac{foa\ aib - fab\ aia}{fa}\bar{h}$$

$$= ajae + ajb\ \bar{n} + ajc\ \bar{h}$$

$$\overline{ssa} = \overline{fa} + pa\ \overline{ai} + qa\ \overline{aj}$$

$$= (faa + pa\ aia + qa\ aja)\bar{e} + (fab + pa\ aib + qa\ ajb)\bar{n}$$

$$+ (fac + pa\ aic + qa\ ajc)\ \bar{h}$$

$$= sse\ \bar{e} + ss\bar{n} + ssh\ \bar{h}.$$

$\overline{ssa}$ is a vector from the camera a focal point to the film frame image point (pa, qa). It has the same direction as the desired unit vector $\overline{sa}$ but its magnitude is in general not 1. So,

$$\overline{sa} = \frac{\overline{ssa}}{/\overline{ssa}/} = \frac{\overline{ssa}}{ssa}$$

where

$$saa = (sse^2 + ssn^2 + ssh^2)^{1/2}$$

$$\overline{sa} = \frac{sse}{ssa}\,\overline{e} + \frac{ssn}{ssa}\,\overline{n} + \frac{ssh}{ssa}\,\overline{h}$$

$$= saa\,\overline{e} + sab\,\overline{n} + sac\,\overline{h}\ .$$

The discussion for camera b is precisely analogous, yielding the desired unit vector

$$sb = sba\,\overline{e} + sbb\,\overline{n} + sbc\,\overline{h}.$$

In determining the solution point the unit vectors $\overline{sa}$ and $\overline{sb}$ in the ray directions must be known at the same instant. Since solutions are desired at equally spaced time points, a method of interpolating between two camera rays is needed.

Although there are timing flash marks on each roll of film which allow the time at which each frame was exposed to be determined very closely, the shutters of the two cameras are not synchronized. Moreover, the picture-taking rates of the two cameras are not quite equal.

Assume that we have two successive frames from either <u>one</u> of the cameras taken at times tas and tbs where tas < tbs. Let the film frame coordinates of the moving point's image be (ppa, qqa) at time tas and (ppb, qqb) at time tbs.

Figure 44 shows vectors $\overline{a}$ and $\overline{b}$ to the image points of the moving object point at times tas and tbs respectively. Now to get what would have been the ray direction to the moving point's image at time ts (tas < ts < tbs), we assume that the ray turns with constant angular velocity through the angle th in time interval tbs - tas. That is, the angle ths turned through in time ts - tas is ths = $\frac{ts - tas}{tbs-tas}$ th. See Figure 45.

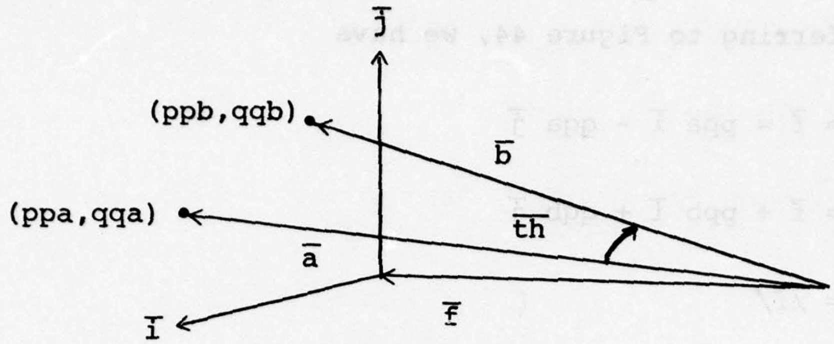


Figure 44.

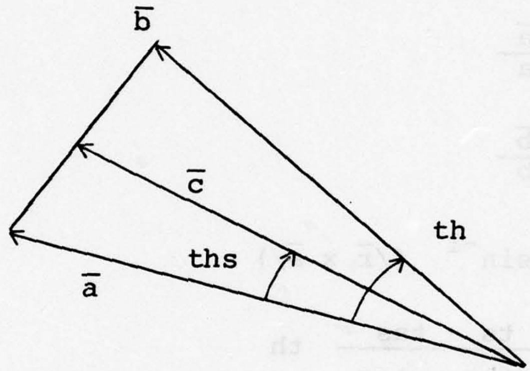


Figure 45.

Figure 45 shows vectors $\bar{a}$, $\bar{b}$, and the angles th and ths. Vector $\bar{c}$ is that vector which picks out on the film frame the image point position that would have occurred had a picture been taken at time ts. (The assumptions that the moving point remains in the plane of its rays $\bar{a}$ and $\bar{b}$ from time tas to time tbs, and that it moves in such a way that its angular velocity with respect to the camera focal point is constant are in general not exactly ture, but if the film frame rate is high enough to faithfully record the experiment, they should be good assumptions. The simple error statistics on the program output seem to indicate the above is a good interpolation.)

Referring to Figure 44, we have

$$\bar{a} = \bar{f} = ppa\ \bar{I} - qqa\ \bar{j}$$

$$b = \bar{f} + ppb\ \bar{I} + qqb\ \bar{j}$$

$$f = /\bar{f}/$$

$$a = /\bar{a}/ = (f^2 + ppa^2 + qqa^2)^{1/2}$$

$$b = /\bar{b}/ = (f^2 + ppb\ + qqb^2)^{1/2}$$

$$\bar{r} = \frac{\bar{a}}{a}$$

$$\bar{s} = \frac{\bar{b}}{b}$$

$$th = \sin^{-1}\ (/\bar{r} \times \bar{s}/)$$

$$ths = \frac{ts - tas}{tbs - tas}\ th$$

$$tht = th - ths.$$

Let $\overline{rs}$ be a unit vector in the direction of c. See Figure 46.

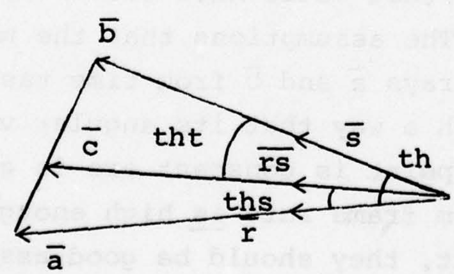


Figure 46.

So,

$$\overline{rs} = A\,\overline{r} + B\,\overline{s} \text{ where A and B must be found.}$$

Dotting through by $\overline{r}$ gives:

$$\overline{r}\,.\,\overline{rs} = A\,\overline{r}\,.\,\overline{r} + B\,\overline{r}\,.\,\overline{s}$$

or $$\cos \text{ths} = A + B \cos \text{th}.$$

Dotting through by $\overline{s}$ gives:

$$\overline{rs}\,.\,\overline{s} - A\,\overline{r}\,.\,\overline{s} + B\,\overline{s}\,.\,\overline{s}$$

or $$\cos \text{tht} = A \cos \text{th} + B$$

$$A = \frac{\begin{vmatrix} \cos \text{ths} & \cos \text{th} \\ \cos \text{tht} & 1 \end{vmatrix}}{\begin{vmatrix} 1 & \cos \text{th} \\ \cos \text{th} & 1 \end{vmatrix}}$$

$$= \frac{\cos(\text{ths}) - \cos \text{th} \cos \text{tht}}{1 - \cos^2 \text{th}}$$

$$= \frac{\cos(\text{th} - \text{tht}) - \cos \text{th} \cos \text{tht}}{\sin^2 \text{th}}$$

$$= \frac{\sin \text{th} \sin \text{tht}}{\sin^2 \text{th}}$$

$$A = \frac{\sin \text{tht}}{\sin \text{th}}$$

$$B = \frac{\begin{vmatrix} 1 & \cos \text{ths} \\ \cos \text{th} & \cos \text{tht} \end{vmatrix}}{\sin^2 \text{th}}$$

$$= \frac{\cos \text{tht} - \cos \text{ths}\,.\,\cos \text{th}}{\sin^2 \text{th}}$$

$$B = \frac{\sin ths}{\sin th} .$$

So,

$$\overline{rs} = A\,\overline{r} + B\,\overline{s}$$

$$\overline{rs} = \frac{\sin tht}{\sin th}\,\overline{r} + \frac{\sin ths}{\sin th}\,\overline{s}$$

where $\overline{rs}$ is a unit vector in the direction of the image of the moving point at time ts.

We need only scale $\overline{rs}$ so that its tip just touches the film frame. See Figure 47.

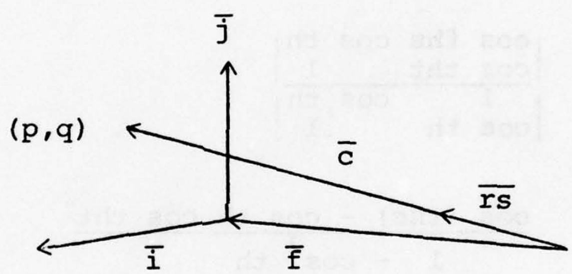


Figure 47.

The length of f is $\overline{f}$, i.e., $f = /\overline{f}/$

$\overline{c} = xk\ \overline{rs}$ where xk must be found.

$xk\ \overline{rs} \cdot \frac{\overline{f}}{f} = f$ (the component of $\overline{c}$ in the direction of the camera optical axis must equal the focal length, f, of the camera.

So,

$$xk = \frac{f^2}{\overline{rs} \cdot \overline{f}}$$

and

$$\bar{c} = xk\,\overline{rs}.$$

The coordinates of the image point at time ts are:

$$(p,q) \text{ where } p = \bar{c} \cdot \bar{i}$$
$$\text{and } q = \bar{c} \cdot \bar{j}\,.$$

This essentially concludes the discussion of the math modeling used in the program. The rest of the program is principally concerned with bookkeeping.

It is worth mentioning that the ray interpolation probably could have been done more economically. However, an additional complication with the runs is that some slight camera movement is experienced during periods of peak sled acceleration. It is very slight on the great majority of runs. There are, however, one or two runs in which camera vibration was rather severe. In order to deal with this problem, additional analysis (not reported in detail) has been done to allow frame-by-frame reorienting of the cameras. To insert this correction into the program would require a different ray interpolation routine.

The assumption of an absolutely rigid camera mounting appears to be justified in view of the data obtained so far. But reorienting of the cameras frame-by-frame might give some improvement. Also, taking the solutions from the program as it presently stands and actually going back and computing the angular accelerations of the moving points at each camera would provide an interesting check on the ray interpolation assumptions presently in the program. It might even allow a reinterpolation and a better final solution.

In short, there are a number of areas that remain to be investigated in this problem, perhaps with profit, perhaps not.

3.2.1 Program SLED

Program SLED uses four subroutines. Its block diagram appears in Figure 48.

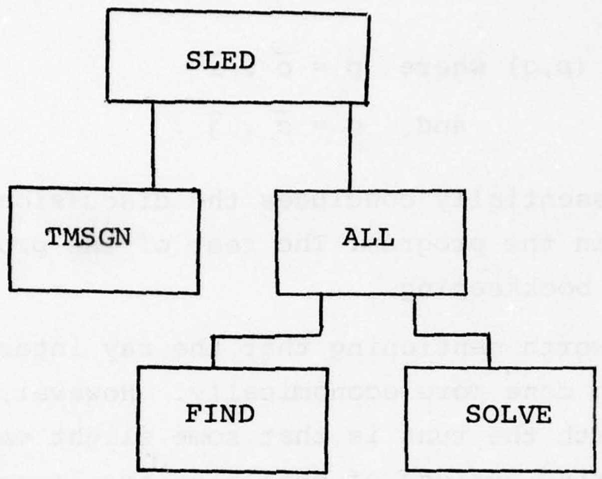


Figure 48. Block Diagram of Program SLED.

A brief overview of the program operation will be given before the more detailed discussion. The main program SLED reads in the input data, scales it where necessary, and writes it out. In broad outline this input data consists of location and orientation data for each of the two cameras and the position coordinates of certain reference points rigidly affixed to the sled. Also, the film frame coordinates of the moving points are input for each of the cameras for each film frame. The film frame coordinates of some of the fixed reference points are also input, but at present no use is being made of this information in program SLED. The time increment desired between solution points is input and a run identification number. The exact reference times for at least two frames are read in for each camera. Subroutine TMSGN (Time Assign) then,by linear interpolation, assigns to each of the other film frames its correct time.

AD-A062 006 DAYTON UNIV OHIO RESEARCH INST F/G 5/5
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Subroutine ALL is then called. It computes the time, ts, at which each of the four moving points is to be determined. It then finds that pair of film frames from each camera whose times bracket the present ts value. Then, for the first targeted point ALL calls FIND once for each camera to get the interpolated rays toward that point at time ts. ALL then calls SOLVE to find the position of the point at time ts. This is done in succession for each of the four moving points on the test subjects. Then, ts is increased by the desired time increment between solution points and the whole process repeated again. This continues until a time, ts, is requested which exceeds the time of the last frame input for one of the cameras. Throughout this process the sum of the two ray solution miss distances are stored for each of the four moving points. Also stored is the sum of the squares of these miss distances. After the four moving points have been located for the last value of ts, the sample mean and sample standard deviation of the miss distances is computed for each of the four points.

The principal symbols used in the program will now be defined. This first list consists of those variables appearing in COMMON. COMMON consists solely of camera location and orientation data.

RAA, RAB, RAC	Camera a position coordinates (feet).
FA	Camera a focal length (feet).
THA	Camera a optical axis azimuth (radians).
PHA	Camera a optical axis elevation (radians).
GA	Camera a tilt angle in radians. Not presently used.
THIA	Azimuth of the camera a film frame $\bar{I}$ factor (radians).
PHIA	Elevation of the camera a film frame $\bar{I}$ vector (radians).

RBA RBB RBC	Camera b positon coordinates (feet).	
FB	Camera b focal length (feet).	
THB	Camera b optical axis azimuth (radians).	
PHB	Camera b optical axis elevation (radians).	
GB	Camera b tilt angle in radians. Not presently used.	
THIB	Camera b $\bar{I}$ axis azimuth (radians).	
PHIB	Camera b $\bar{I}$ axis elevation (radians).	

The next part of the symbol list consists principally of the dimensioned variables used by the program. A short discussion follows this list.

NA	Number of frames of camera a data.
NFRA(I), I = 1, NA	Frame number of the ith frame of camera a data.
NB	Number of frames of camera b data.
NFRB(I), I = 1, NB	Frame number of the ith frame of camera b data.
TA(I), I = 1, NA	Time at which camera a shot ith frame (seconds).
TB(I), I = 1, NB	Time at which camera b shot ith frame (seconds).
XA(I,J), I = 1, NA; J = 1, 8	The horizontal film frame coordinate of the jth image point on the ith film frame of camera a (counts: 1000/counts/inch).
YA (I,J), I = 1, NA; J = 1, 8	The vertical film frame coordinate of the jth image point on the ith film frame of camera a (counts: 1000/counts/inch).
XB (I,J), I = 1, NB; J = 1, 8 YB (I,J), I = 1, NB; J = 1, 8	The analogous quantities for camera b.

NREFA(I), I = 1, 10 TREFA (I), I = 1, 10	Up to 10 camera a frame numbers and their associated times may be read in and used by TMSGN to assign the correct times to all the camera a film frames (TREFA (I) values in seconds).
NREFB(I), I = 1, 10 TREFB(I), I = 1, 10	The analogous quantities for camera b. In practice only two reference frame numbers and times need be used.
SMEAN (J), J = 5, 8 SSDEV(J), J = 5, 8	The sample mean and the sample standard deviation of the two-ray-solution miss distances for each of the four targeted points (inches).
XX(10) YY(10) ZZ(10)	The position coordinates of up to 10 reference points rigidly attached to the sled (feet).

The above list can be further clarified by discussing those quantities in the above list that pertain only to camera a. The cameras are brought up to speed shortly before the sled begins to accelerate in order that the picture-taking rate of each camera be constant during the actual experiment. Thus, the first frame of camera a containing data of interest might be frame 80. Assume there are 33 frames of camera a data numbered consecutively from 80 to 112.

Then NA = 33
NFRA(1) = 80
NFRA(2) = 81
.
.
.
NFRA(33) = 112

Now there are eight points on each of these frames whose coordinates are read on the film frame reader. The program stores these as XA (I,J), YA(I,J) I = 1, 33; J = 1, 8. Thus, the fifth point read on the ninth frame would have coordinates XA (9,5), YA (9,5). This is on frame number 88, i.e., NFRA (9) = 88.

The cameras do run at a constant rate once they have come up to speed. There are timing flashes of light superimposed on the negative from which the time an individual frame was shot can be determined quite accurately. Suppose that frame 80 is found to have been taken at time 0.142 seconds and frame 112 at 0.208 seconds. Then the program would store

NREFA(1) = 80 NREFA (2) = 112

TREFA(1) = 0.142 TREFA (2) = 0.208.

Subroutine TMSGN then assigns the correct time to each frame of camera a data by linear interpolation and stores them in TA(I), I = 1, 33, i.e.,

TA (1) = 0.142

TA (2) = 0.144

.

.

.

TA (32) = 0.206

TA (33) = 0.208.

It is not necessary to use the first and last frame of data. Had frames 88 and 99 been used as reference frames, TMSGN would linearly extrapolate to those frames outside the interval.

Precisely the same discussion applies to those variables associated with camera b. Since the two cameras are not synchronized, the only connection between their data is the time flash which is inscribed on both film strips simultaneously. Thus, camera a and camera b in general have different numbers of frames and in general, no two frames from a and b are snapped simultaneously. Moreover, it is generally true that a test time ts at which the positon of the moving points are to be output is not coincident with that of any frame from either camera.

The input for the program will now be discussed.

The first four cards contain the location and orientation information for camera a and b as follows:

Cards 1 and 2: RAA, RAB, RAC, FA, THA, PHA, GA
THIA, PHIA
Format (4F10.0/5F10.0)

Cards 3 and 4: RBA, RBB, RBC, FB, THB, PHB, GB, THIB,
PHIB
Format (4F 10.0/5F10.0).

The input of camera a and camera b film frame data is terminated by signal cards at the ends of their respective data decks. The numbers NA and NB are determined during the read-in of this data. The data for each film frame requires two cards. The first card for each frame contains the frame number and then the film frame coordinates for the images of the four fixed points. The second card contains the same frame number and then the film frame coordinates for the four moving points. NA is incremented by one as the two cards for each new frame of camera a data are read in.

Camera a data input for each frame

NFRA(NA),((XA(NA,I), YA(NA,I)),I = 1, 8)
Format (I5, 8F7.0/5X, 8F7.0).

Termination cards for camera a input consists of two cards, the first with 9's in columns 1-5, the second blank.

99999
A BLANK CARD

Camera b data input for each frame is

NFRB(NB), ((XB(NB,I), YB(NB,I)), I = 1, 8)
Format (I5, 8F7.0 / 5X, 8F7.0).

Termination is the same as camera a.

99999
A BLANK CARD.

Next the position coordinates of some reference points are read in. NHP, the number of reference points, is defined as they are read in. Again, the read-in is terminated by a signal card. The format is

XX(NHP), YY(NHP), ZZ(NHP)

Format (3F10.0).

The termination card has 100000.0 punched in the first ten columns and is otherwise blank.

The reference times and the reference frame numbers for camera a are then input to the program. NTMA, the number of reference times for camera a, is determined when the read-in is terminated by a card with 99999 in columns 12-16.

Camera a data input for each reference time and frame number is

TREFA (NTMA), NREFA (NTMA)

Format (F10.0, I6)

The termination card is

99999 (in columns 12-16).

The camera b time reference input is precisely analogous and is terminated in the same way.

TREFB (NTMB), NREFB (NTMB)

Format (F10.0, I6)

with termination card

99999 (in columns 12-16).

The last input card contains the run identification number DESIG and the time increment DT (in seconds) desired between position solutions for the moving points. The format is

DT, DESIG

Format (2F10.0).

Figure 49 indicates the various sections of a typical input deck.

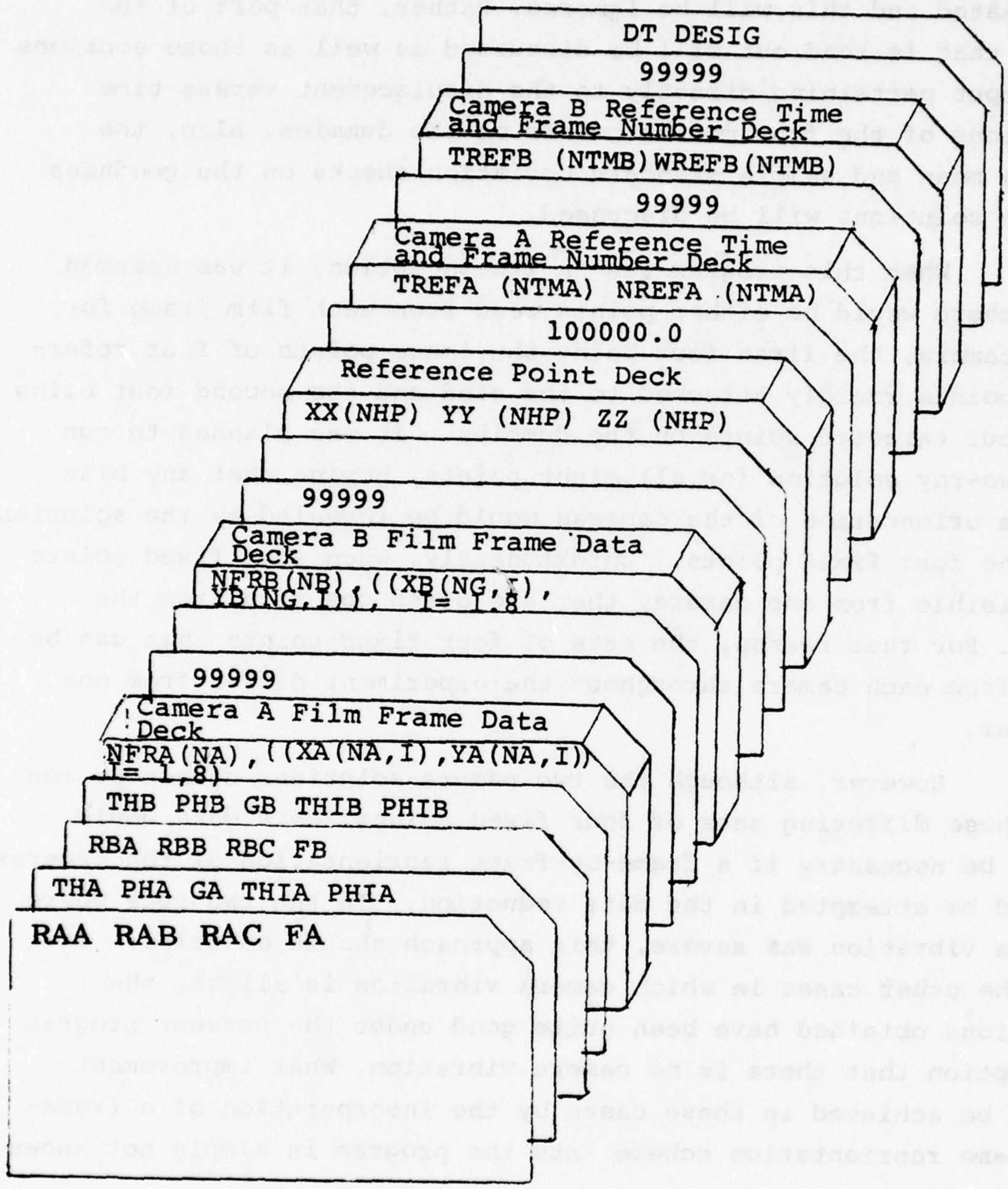


Figure 49. Typical Data Deck Input to Program SLED.

There is a great deal of output presently taken from the program. Much of this is debug output which can now be eliminated and this will be ignored. Rather, that part of the input that is read out will be discussed as well as those sections of output pertaining directly to the displacement versus time solutions of the four moving points on the dummies. Also, the sample mean and sample standard deviation checks on the goodness of the solutions will be discussed.

When this program was in its inception, it was assumed that there would be either points read from each film frame for each camera, the first four being the image points of four reference points rigidly attached to the sled and the second four being the four targeted points on the dummies. It was planned to run the two-ray solution for all eight points, hoping that any bias in the orientation of the cameras would be revealed by the solutions for the four fixed points. Unfortunately, when some fixed points are visible from one camera, they are often obscured from the other. For that reason, the sets of four fixed-points that can be read from each camera throughout the experiment differ from one another.

However, although the two camera solutions cannot be run for these differing sets of four fixed points, this data would still be necessary if a frame-by-frame reorientation of the cameras should be attempted in the data reduction. In the two runs where camera vibration was severe, this approach should be tried. In all the other cases in which camera vibration is slight, the solutions obtained have been quite good under the present program assumption that there is no camera vibration. What improvement could be achieved in these cases by the incorporation of a frame-by-frame reorientation scheme into the program is simply not known at this time.

As the program presently stands, it makes no use whatsoever of the first four image points read in for each frame of each camera. Nor is any use made of position coordinates of the

reference points read in. This information is being retained with a view as to modifications yet to be made to program SLED. For the above reasons, the sample mean and sample standard deviation read-out for the first four points are recorded as 0.0 since no solutions are attempted for these points.

Figure 50 is a tab page showing some of the output. The first two lines are the camera location and orientation data for cameras a and b. Position coordinates and focal lengths are in feet and all the angles in radians.

The bracketed data immediately below consists of the position coordinates of each of the reference points input. These are in feet and are given with respect to the program right-hand coordinate system as are the camera positions above. The reference times are in seconds. Part of the frame data for camera a is output. There are three lines for each frame of data. Taking the first frame as an example, the "1" identifies this as the first frame of camera a data, the "80" is the film frame number, and the .141864E + 00 is the time in seconds at which it was snapped. The next line gives the film frame image coordinates of the four fixed points read for camera a and the following line contains the coordinates of the four targeted points on the dummies. All these film frame image coordinates are output in feet. After all the film frame data for both cameras a and b has been output, the time increment, dt, desired between solution positions for each of the four points is printed out in seconds. Refer to the complete listing beginning on page F-15 to see this.

Figure 51 displays that page of the tab on which the sample mean and the sample standard deviation for each of the four targeted points (point numbers 5 through 8) are provided. These quantities are the mean and the standard deviation of all the miss distances, d, in the two-ray solutions for each of the moving points. They are output in inches.

```
CAMERA DATA RAA        RAB            RAC            FA             THA            PHA            GA             THIA           PHIA
-.346811E+01  .318643E+01  .377726E+01  .666667E+00 -.585559E+00 -.313279E+00  .413188E-01  .374504E+00  .392092E-01
CAMERA DATA RBA        RBB            RBC            FB             THA            PHB            GB             THIB           PHIB
-.337545E+01 -.339973E+01  .363636E+01  .672340E+00  .542761E+00 -.299090E+00  .147729E-01  .221308E+01  .141190E-01
HARD PT LOCATIONS   .378917E+01  .143750E+01  .376833E+01
HARD PT LOCATIONS   .380167E+01  .325830E+00  .376333E+01
HARD PT LOCATIONS   .381000E+01 -.640930E+00  .376583E+01
HARD PT LOCATIONS   .550000E-01  .109333E+01  .406670E+00
HARD PT LOCATIONS   .733300E-01  .583330E+00  .643330E+00
HARD PT LOCATIONS   .733300E-01 -.551670E+00  .655670E+00
HARD PT LOCATIONS   .375000E-01 -.106250E+01  .507500E+00
HARD PT LOCATIONS   .758300E-01 0.                .676670E+00
HARD PT LOCATIONS   .750000E-02 0.                .291670E+00
REF TIMES&FRAME NOS   .141064E+00    80     2
REF TIMES&FRAME NOS   .208136E+00   112     2
REF TIMES&FRAME NOS   .140412E+00    80     2
REF TIMES&FRAME NOS   .198144E+00   105     2
   1     80   .141064E+00
 .153333E+00  .213583E+00   .511667E-01   .213750E+00 -.101083E+00 -.218667E+00 -.257417E+00 -.198667E+00
 .732500E-01  .139833E+00   .477500E-01   .127333E+00 -.153167E+00  .131750E+00 -.139000E+00  .635833E-01
   2     81   .143935E+00
 .153750E+00  .213167E+00   .619167E-01   .213417E+00 -.101000E+00 -.219083E+00 -.257750E+00 -.196167E+00
 .713333E-01  .138417E+00   .456667E-01   .125500E+00 -.155750E+00  .129500E+00 -.138917E+00  .805000E-01
   3     82   .146006E+00
 .153833E+00  .212417E+00   .623333E-01   .212917E+00 -.101250E+00 -.219000E+00 -.257583E+00 -.197667E+00
 .696667E-01  .134833E+00   .416667E-01   .124167E+00 -.157417E+00  .123667E+00 -.138500E+00  .767500E-01
   4     83   .148077E+00
 .153917E+00  .211917E+00   .625833E-01   .212417E+00 -.101500E+00 -.219250E+00 -.257633E+00 -.198083E+00
 .662500E-01  .132250E+00   .395833E-01   .122833E+00 -.158750E+00  .119667E+00 -.138250E+00  .746667E-01
   5     84   .150148E+00
 .153667E+00  .213167E+00   .619333E-01   .213583E+00 -.101500E+00 -.218083E+00 -.258500E+00 -.197667E+00
 .639167E-01  .132250E+00   .388333E-01   .121083E+00 -.160917E+00  .116750E+00 -.137000E+00  .738333E-01
   6     85   .152219E+00
 .153333E+00  .214417E+00   .613333E-01   .215083E+00 -.100917E+00 -.217583E+00 -.258167E+00 -.196583E+00
 .612500E-01  .128250E+00   .391667E-01   .117583E+00 -.162750E+00  .113250E+00 -.136500E+00  .719167E-01
   7     86   .154290E+00
 .152500E+00  .215833E+00   .606667E-01   .215833E+00 -.100583E+00 -.217750E+00 -.258167E+00 -.196583E+00
 .599167E-01  .124167E+00   .392500E-01   .113417E+00 -.164000E+00  .108917E+00 -.134500E+00  .698333E-01
   8     87   .156361E+00
 .151500E+00  .216583E+00   .595000E-01   .216583E+00 -.999167E-01 -.218167E+00 -.257250E+00 -.197583E+00
 .589333E-01  .117750E+00   .401667E-01   .106750E+00 -.165167E+00  .103917E+00 -.134633E+00  .657500E-01
   9     88   .158432E+00
 .150833E+00  .216917E+00   .597500E-01   .216500E+00 -.994167E-01 -.217333E+00 -.257167E+00 -.198083E+00
 .570000E-01  .112083E+00   .411667E-01   .977500E-01 -.164583E+00  .994167E-01 -.133833E+00  .640000E-01
  10     89   .160503E+00
 .150750E+00  .216583E+00   .590000E-01   .215833E+00 -.995833E-01 -.217667E+00 -.257500E+00 -.198500E+00
 .579167E-01  .105333E+00   .420000E-01   .898333E-01 -.164250E+00  .965000E-01 -.130917E+00  .625000E-01
  11     90   .162574E+00
 .151417E+00  .217083E+00   .598333E-01   .216750E+00 -.995833E-01 -.217667E+00 -.257500E+00 -.196833E+00
 .574167E-01  .990833E-01   .441667E-01   .804167E-01 -.163417E+00  .936667E-01 -.128917E+00  .623333E-01
  12     91   .164645E+00
 .151333E+00  .217250E+00   .598333E-01   .216833E+00 -.101750E+00 -.207083E+00 -.258167E+00 -.187000E+00
 .581667E-01  .100417E+00   .460833E-01   .784167E-01 -.162083E+00  .100667E+00 -.127333E+00  .705833E-01
  13     92   .166716E+00
 .152583E+00  .216167E+00   .612500E-01   .216167E+00 -.102000E+00 -.217250E+00 -.258333E+00 -.195917E+00
 .590000E-01  .830000E-01   .502500E-01   .572500E-01 -.161417E+00  .889167E-01 -.123667E+00  .604167E-01
  14     93   .168787E+00
 .152583E+00  .216000E+00   .605833E-01   .216000E+00 -.102833E+00 -.216917E+00 -.258333E+00 -.195500E+00
 .589333E-01  .752500E-01   .533333E-01   .444167E-01 -.159417E+00  .860833E-01 -.123083E+00  .601667E-01
  15     94   .170858E+00
 .152250E+00  .214250E+00   .605000E-01   .214250E+00 -.102583E+00 -.217333E+00 -.259000E+00 -.196583E+00
 .576667E-01  .675000E-01   .576667E-01   .314167E-01 -.159083E+00  .840833E-01 -.121167E+00  .582500E-01
  16     95   .172929E+00
 .151750E+00  .214833E+00   .602500E-01   .214833E+00 -.103167E+00 -.217333E+00 -.259083E+00 -.196833E+00
 .562500E-01  .613333E-01   .601667E-01   .229167E-01 -.159667E+00  .816667E-01 -.116667E+00  .576667E-01
  17     96   .175000E+00
```

Reference Point Position Coordinates (HARD PT LOCATIONS lines)

Reference Times and Frame Numbers for Camera A (first two REF TIMES&FRAME NOS lines)

Reference Times and Frame Numbers for Camera B (last two REF TIMES&FRAME NOS lines)

First Frame of Camera A Data (the two data lines after "1 80")

Figure 50. Typical Listing of Data Input to Program SLED.

```
FIND   .202268E+00 -.150750E+00  .465000E-01 -.152333E+00  .500000E-01  .204000E+00
SOLVE -.150586E+00  .900921E-01 -.152060E+00  .494396E-01  .700617E+00  .110425E+01  .224636E+01  126
FIND   .203994E+00 -.113417E+00  .600000E-01 -.117750E+00  .612500E-01  .204000E+00
FIND   .202268E+00 -.149167E+00  .199167E-01 -.149750E+00  .195633E-01  .204000E+00
SOLVE -.113429E+00  .600036E-01 -.149657E+00  .196367E-01  .945409E+00 -.149721E+01  .255607E+01  127
CORR  -.588556E+00 -.321360E+00  .977255E+00  .149717E-01  .157796E-01
       .644825E+00 -.299439E+00  .220592E+01  .300166E-01  .326785E-01
FIND   .203994E+00  .593333E-01  .250000E-01  .610000E-01  .259167E-01  .206000E+00
FIND   .204330E+00  .104167E+00  .551667E-01  .101667E+00  .552500E-01  .206000E+00
SOLVE  .603476E-01  .258879E-01  .102141E+00  .552342E-01  .128178E+01 -.134204E+01  .223482E+01  128
FIND   .203994E+00  .765833E-01 -.975000E-02  .794167E-01 -.608333E-02  .206000E+00
FIND   .204330E+00  .126917E+00  .500000E-01  .130667E+00  .430000E-01  .206000E+00
SOLVE  .793276E-01 -.813573E-02  .129954E+00  .491901E-01  .824996E+00  .876576E+00  .237075E+01  129
FIND   .203994E+00 -.150583E+00  .900833E-01 -.151667E+00  .931667E-01  .206000E+00
FIND   .204330E+00 -.152333E+00  .500000E-01 -.156250E+00  .528333E-01  .206000E+00
SOLVE -.151633E+00  .930697E-01 -.155505E+00  .522943E-01  .695149E+00  .112611E+01  .224945E+01  130
FIND   .203994E+00 -.113417E+00  .600000E-01 -.117750E+00  .612500E-01  .206000E+00
FIND   .204330E+00 -.149750E+00  .195833E-01 -.153667E+00  .159167E-01  .206000E+00
SOLVE -.117614E+00  .612107E-01 -.152922E+00  .166140E-01  .952893E+00 -.151842E+01  .257922E+01  131
CORR  -.588473E+00 -.321274E+00  .977112E+00  .156571E-01  .165015E-01
       .644774E+00 -.299451E+00  .220601E+01  .295619E-01  .323806E-01
FIND   .206065E+00  .610000E-01  .259167E-01  .631667E-01  .295000E-01  .208000E+00
FIND   .206392E+00  .101667E+00  .552500E-01  .101417E+00  .550000E-01  .208000E+00
SOLVE  .630242E-01  .292644E-01  .101472E+00  .550550E-01  .126043E+01 -.138088E+01  .223321E+01  132
FIND   .206065E+00  .794167E-01 -.808333E-02  .813333E-01 -.341667E-02  .208000E+00
FIND   .206392E+00  .130667E+00  .490000E-01  .131000E+00  .480833E-01  .208000E+00
SOLVE  .812074E-01 -.372341E-02  .130927E+00  .482850E-01  .941703E+00  .881044E+00  .238001E+01  133
FIND   .206065E+00 -.151667E+00  .931667E-01 -.149417E+00  .981667E-01  .208000E+00
FIND   .206392E+00 -.156250E+00  .528333E-01 -.156750E+00  .526667E-01  .208000E+00
SOLVE -.149565E+00  .978380E-01 -.156640E+00  .527033E-01  .697825E+00  .113392E+01  .226163E+01  134
FIND   .206065E+00 -.117750E+00  .612500E-01 -.115667E+00  .633333E-01  .208000E+00
FIND   .206392E+00 -.153667E+00  .159167E-01 -.154250E+00  .159167E-01  .208000E+00
SOLVE -.115604E+00  .631965E-01 -.154122E+00  .159167E-01  .976798E+00 -.151894E+01  .259988E+01  135
CORR  -.588416E+00 -.321290E+00  .976985E+00  .162101E-01  .170844E-01
       .644703E+00 -.299369E+00  .220610E+01  .290898E-01  .318618E-01
NO OF PTS,PT NO,MEAN,DEV    34    1 0.             0.
NO OF PTS,PT NO,MEAN,DEV    34    2 0.             0.
NO OF PTS,PT NO,MEAN,DEV    34    3 0.             0.
NO OF PTS,PT NO,MEAN,DEV    34    4 0.             0.
NO OF PTS,PT NO,MEAN,DEV    34    5  .658133E+00  .249503E+00
NO OF PTS,PT NO,MEAN,DEV    34    6  .776817E+00  .395669E+00
NO OF PTS,PT NO,MEAN,DEV    34    7  .245523E+00  .142561E+00
NO OF PTS,PT NO,MEAN,DEV    34    8  .847961E+00  .670091E+00
.142 11.57-10.07 38.30  7.90 -9.64 37.36 RUN  680. PTS  5 AND  6  .381361E+01  .994790E+00  .123246E+01
.144 10.96-10.21 38.24  7.46 -9.70 37.28 RUN  680. PTS  5 AND  6  .366363E+01  .981252E+00  .118891E+01
.146 10.53-10.32 38.09  6.92 -9.66 37.24 RUN  680. PTS  5 AND  6  .376601E+01  .781985E+00  .114239E+01
.148  9.85-10.38 37.98  6.38 -9.79 37.27 RUN  680. PTS  5 AND  6  .359585E+01  .686943E+00  .998137E+00
.150  9.22-10.49 37.93  5.98 -9.97 37.22 RUN  680. PTS  5 AND  6  .336167E+01  .900878E+00  .940312E+00
.152  8.67-10.57 37.70  5.67-10.20 37.07 RUN  680. PTS  5 AND  6  .308748E+01  .859161E+00  .821924E+00
.154  8.24-10.69 37.42  5.26-10.46 36.79 RUN  680. PTS  5 AND  6  .304960E+01  .866799E+00  .863434E+00
.156  7.83-10.85 37.01  4.94-10.76 36.37 RUN  680. PTS  5 AND  6  .296415E+01  .801822E+00  .864760E+00
.158  7.38-10.98 36.62  4.64-11.07 35.85 RUN  680. PTS  5 AND  6  .284278E+01  .773129E+00  .706766E+00
.160  7.00-11.26 36.17  4.27-11.41 35.30 RUN  680. PTS  5 AND  6  .287456E+01  .770970E+00  .730944E+00
.162  6.74-11.42 35.69  4.06-11.73 34.64 RUN  680. PTS  5 AND  6  .290028E+01  .806413E+00  .781920E+00
.164  6.63-11.50 35.43  3.97-11.96 34.17 RUN  680. PTS  5 AND  6  .297612E+01  .124887E+01  .115226E+01
.166  6.62-11.66 34.72  3.96-12.37 33.26 RUN  680. PTS  5 AND  6  .311219E+01  .874235E+00  .753161E+00
.168  6.61-11.77 34.02  4.00-12.76 32.23 RUN  680. PTS  5 AND  6  .331528E+01  .492256E+00  .426464E+00
.170  6.46-11.84 33.44  4.11-13.11 31.21 RUN  680. PTS  5 AND  6  .348010E+01  .438404E+00  .464156E+00
.172  6.52-11.71 32.78  4.41-13.29 30.26 RUN  680. PTS  5 AND  6  .364792E+01  .570896E+00  .620872E+00
.174  6.54-11.63 32.22  4.73-13.27 29.49 RUN  680. PTS  5 AND  6  .365967E+01  .761358E+00  .624239E+00
.176  6.54-11.57 31.75  4.94-13.10 28.72 RUN  680. PTS  5 AND  6  .375794E+01  .809497E+00  .517122E+00
.178  6.71-11.35 31.31  5.15-12.76 28.10 RUN  680. PTS  5 AND  6  .383673E+01  .735467E+00  .323390E+00
.180  5.70-11.26 30.98  5.27-12.60 27.84 RUN  680. PTS  5 AND  6  .369901E+01  .627485E+00  .538444E+00
.182  6.77-11.18 30.59  5.63-12.79 27.82 RUN  680. PTS  5 AND  6  .339556E+01  .594619E+00  .660283E+00
.184  6.86-11.11 30.20  6.23-12.97 27.50 RUN  680. PTS  5 AND  6  .333760E+01  .629389E+00  .412102E+00
.186  7.15-11.00 29.95  6.08-12.99 27.03 RUN  680. PTS  5 AND  6  .368978E+01  .380945E+00  .315409E+00
```

Sample Means and Standard Deviations for Points 5 through 8

Figure 51. Typical Listing of Data Output from Program SLED.

The last section of output gives the positions of the moving points on the subjects versus time. See Figure 52.

The position versus time data is first output for points 5 and 6, the forehead and chin of the subject in the passenger seat. The first quantity is the time in seconds. The next three numbers are the x, y, and z coordinates of point five in inches. The next three numbers are the coordinates of point six in inches. The coordinates of the moving points are output with respect to the original left-hand experimental coordinate system affixed to the sled. The run number is just an identifier. Then points 5 and 6 are specified. All this data is also punched out on cards for input to other programs. The last three numbers of each line of this output are not punched on the cards.

These numbers are debug output. The first is the distance between the point pair 5 and 6 to the left. The second and third are the miss distance, d, that occurred in the computation of the positions of points 5 and 6.

A complete listing of program SLED is presented in Appendix F.

```
FIND   .202268E+00 -.150750E+00  .465000E-01 -.152333E+00  .500000E-01  .204000E+00
SOLVE -.150586E+00  .900921E-01 -.152060E+00  .494396E-01  .700617E+00  .110425E+01  .224636E+01  126
FIND   .203994E+00 -.113417E+00  .600000E-01 -.117750E+00  .612500E-01  .204000E+00
FIND   .202268E+00 -.149167E+00  .199167E-01 -.149750E+00  .195633E-01  .204000E+00
SOLVE -.113429E+00  .600036E-01 -.149657E+00  .196367E-01  .945409E+00 -.149721E+01  .255607E+01  127
CORR  -.588556E+00 -.321360E+00  .977255E+00  .149717E-01  .157796E-01
       .644825E+00 -.299439E+00  .220592E+01  .300166E-01  .326785E-01
FIND   .203994E+00  .593333E-01  .250000E-01  .610000E-01  .259167E-01  .206000E+00
FIND   .204330E+00  .104167E+00  .551667E-01  .101667E+00  .552500E-01  .206000E+00
SOLVE  .603476E-01  .258579E-01  .102141E+00  .552342E-01  .128178E+01 -.134204E+01  .223482E+01  128
FIND   .203994E+00  .765833E-01 -.975000E-02  .794167E-01 -.608333E-02  .206000E+00
FIND   .204330E+00  .126917E+00  .500000E-01  .130667E+00  .430000E-01  .206000E+00
SOLVE  .793276E-01 -.813573E-02  .129954E+00  .491901E-01  .824996E+00  .876576E+00  .237075E+01  129
FIND   .203994E+00 -.150583E+00  .900833E-01 -.151667E+00  .931667E-01  .206000E+00
FIND   .204330E+00 -.152333E+00  .500000E-01 -.156250E+00  .528333E-01  .206000E+00
SOLVE -.151633E+00  .930697E-01 -.155505E+00  .522943E-01  .695149E+00  .112611E+01  .224945E+01  130
FIND   .203994E+00 -.113417E+00  .600000E-01 -.117750E+00  .612500E-01  .206000E+00
FIND   .204330E+00 -.149750E+00  .195833E-01 -.153667E+00  .159167E-01  .206000E+00
SOLVE -.117614E+00  .612107E-01 -.152322E+00  .166140E-01  .952893E+00 -.151842E+01  .257922E+01  131
CORR  -.588473E+00 -.321274E+00  .977112E+00  .156571E-01  .165015E-01
       .644774E+00 -.299451E+00  .220601E+01  .295619E-01  .323806E-01
FIND   .206065E+00  .610000E-01  .259167E-01  .631667E-01  .295000E-01  .208000E+00
FIND   .206392E+00  .101667E+00  .552500E-01  .101417E+00  .550000E-01  .208000E+00
SOLVE  .630242E-01  .292644E-01  .101472E+00  .550550E-01  .126043E+01 -.138088E+01  .223321E+01  132
FIND   .206065E+00  .794167E-01 -.808333E-02  .813333E-01 -.341667E-02  .208000E+00
FIND   .206392E+00  .130667E+00  .490000E-01  .131000E+00  .480833E-01  .208000E+00
SOLVE  .812074E-01 -.372341E-02  .130927E+00  .482850E-01  .341703E+00  .881044E+00  .238001E+01  133
FIND   .206065E+00 -.151667E+00  .931667E-01 -.149417E+00  .981667E-01  .208000E+00
FIND   .206392E+00 -.156250E+00  .528333E-01 -.156750E+00  .526667E-01  .208000E+00
SOLVE -.149565E+00  .978380E-01 -.156640E+00  .527033E-01  .697825E+00  .113392E+01  .226163E+01  134
FIND   .206065E+00 -.117750E+00  .612500E-01 -.115667E+00  .633333E-01  .208000E+00
FIND   .206392E+00 -.153667E+00  .159167E-01 -.154250E+00  .159167E-01  .208000E+00
SOLVE -.115804E+00  .631965E-01 -.154122E+00  .159167E-01  .976798E+00 -.151894E+01  .259988E+01  135
CORR  -.588416E+00 -.321290E+00  .976985E+00  .162101E-01  .170844E-01
       .644703E+00 -.299369E+00  .220610E+01  .290898E-01  .318618E-01
NO OF PTS,PT NO,MEAN,DEV    34    1 0.              0.
NO OF PTS,PT NO,MEAN,DEV    34    2 0.              0.
NO OF PTS,PT NO,MEAN,DEV    34    3 0.              0.
NO OF PTS,PT NO,MEAN,DEV    34    4 0.              0.
NO OF PTS,PT NO,MEAN,DEV    34    5  .658133E+00  .249503E+00
NO OF PTS,PT NO,MEAN,DEV    34    6  .776817E+00  .395669E+00
NO OF PTS,PT NO,MEAN,DEV    34    7  .245523E+00  .142561E+00
NO OF PTS,PT NO,MEAN,DEV    34    8  .847961E+00  .670091E+00
.142 11.57-10.07 38.30  7.90 -9.64 37.36 RUN  680. PTS  5 AND  6  .381361E+01  .994790E+00  .123246E+01
.144 10.96-10.21 38.24  7.46 -9.70 37.26 RUN  680. PTS  5 AND  6  .366363E+01  .981252E+00  .118891E+01
.146 10.53-10.32 38.09  6.92 -9.66 37.24 RUN  680. PTS  5 AND  6  .376601E+01  .781985E+00  .114239E+01
.148  9.85-10.38 37.98  6.38 -9.79 37.27 RUN  680. PTS  5 AND  6  .359585E+01  .686943E+00  .998137E+00
.150  9.22-10.49 37.93  5.98 -9.97 37.22 RUN  680. PTS  5 AND  6  .336167E+01  .900878E+00  .940312E+00
.152  8.67-10.57 37.70  5.67-10.20 37.07 RUN  680. PTS  5 AND  6  .308748E+01  .859161E+00  .821924E+00
.154  8.24-10.69 37.42  5.26-10.46 36.79 RUN  680. PTS  5 AND  6  .304960E+01  .866799E+00  .863434E+00
.156  7.83-10.85 37.01  4.94-10.76 36.37 RUN  680. PTS  5 AND  6  .296415E+01  .801622E+00  .864760E+00
.158  7.38-10.98 36.62  4.64-11.07 35.85 RUN  680. PTS  5 AND  6  .284278E+01  .773129E+00  .706766E+00
.160  7.00-11.26 36.17  4.27-11.41 35.30 RUN  680. PTS  5 AND  6  .287456E+01  .770970E+00  .730944E+00
.162  6.74-11.42 35.69  4.06-11.73 34.64 RUN  680. PTS  5 AND  6  .290028E+01  .806413E+00  .781920E+00
.164  5.63-11.50 35.43  3.97-11.96 34.17 RUN  680. PTS  5 AND  6  .297812E+01  .124887E+01  .115226E+01
.166  6.62-11.66 34.72  3.96-12.37 33.26 RUN  680. PTS  5 AND  6  .311219E+01  .874239E+00  .753161E+00
.168  6.61-11.77 34.02  4.00-12.76 32.23 RUN  680. PTS  5 AND  6  .331528E+01  .492256E+00  .426464E+00
.170  6.46-11.84 33.44  4.11-13.11 31.21 RUN  680. PTS  5 AND  6  .348010E+01  .438404E+00  .464156E+00
.172  6.52-11.71 32.78  4.41-13.29 30.26 RUN  680. PTS  5 AND  6  .364792E+01  .570896E+00  .620872E+00
.174  6.54-11.63 32.22  4.73-13.27 29.49 RUN  680. PTS  5 AND  6  .365967E+01  .761358E+00  .624239E+00
.176  6.54-11.57 31.75  4.94-13.10 28.72 RUN  680. PTS  5 AND  6  .375794E+01  .809497E+00  .517122E+00
.178  6.71-11.35 31.31  5.15-12.76 28.10 RUN  680. PTS  5 AND  6  .383673E+01  .735467E+00  .323390E+00
.180  5.70-11.26 30.98  5.27-12.60 27.84 RUN  680. PTS  5 AND  6  .369901E+01  .627485E+00  .538444E+00
.182  6.77-11.18 30.59  5.67-12.79 27.82 RUN  680. PTS  5 AND  6  .339556E+01  .594619E+00  .660283E+00
.184  6.86-11.11 30.20  6.23-12.97 27.50 RUN  680. PTS  5 AND  6  .333760E+01  .629389E+00  .412102E+00
.186  7.15-11.00 29.95  6.08-12.99 27.03 RUN  680. PTS  5 AND  6  .368978E+01  .380945E+00  .315409E+00
```

Point 5 and 6
Positions versus
Time in Seconds

Figure 52. Typical Listing of Solutions Output from Program SLED.

SECTION 4
CONCLUSIONS AND RECOMMENDATIONS

The processes developed and applied during the period of performance have satisfied the basic requirements for which they were developed. There is still much that could be accomplished to refine the programs for the purposes of improving cost effectiveness and user confidence in the solutions generated. Continuing review is recommended for the purpose of accomplishing the following.

A. Modify program HIFPD to include a computerized analysis of differences between the raw and smoothed solution points.

B. Modify program HIFPD to provide computerized calculations of conversion factors for the various anthropometric points being tracked.

C. Investigate the desirability of employing smoothing techniques other than the moving arc quadratic fit currently being used.

D. Determine accuracy requirements and criteria for analyzing the accuracy of solutions prior to applications of these processes to future studies.

APPENDIX A

DESCRIPTION OF PROGRAM HIFPD INPUT DATA AND PARAMETER CODES

DESCRIPTION OF PROGRAM INPUT DATA AND PARAMETER CODES

I. PROGRAM SETUP CARDS

A) The first card in the setup deck must contain the date in columns 1 to 10; for example, 12 FEB 74 or FEB 11,74 (only one date card per job).

B) The following four cards are required for each test in the computer job:

<u>Card Number 1</u>

Column	Format	Data Description
1-5	A5	Test number
6	11	IRX--flag controlling polarity of X-axis data- blank or 0---no change 1---change sign of X-axis data
7	11	IPR--flag controlling input data and difference printout -blank or 0---print data 1---omit printout
8	11	ITYPE--flag controlling input data-blank or 0 ---read and process all 8 variables 1 ---read and process only variables 1,2,7, and 8
9	11	IPL--flag controlling linear velocity and and acceleration data -blank or 0---print and plot data 1---print only 2---omit all linear data
11	11	IPA--flag controlling angular velocity and acceleration data (shoulder-hip and head pt.1, head pt.2)--blank or 0---print and plot data 1---print only 2---omit all angular data
13	11	IPC--flag controlling variable displacement with respect to sled data -blank or 0---print and plot data 1---print only 2---omit these computations
14-16	13	First frame included in displacement with respect to the sled plot (if blank, the first available frame is plotted).
17-19	13	Last frame in displacement with respect to the sled plot (if blank, the last frame is plotted).

Card Number 2 (Continued)

Column	Format	Data Description
20-21	12	The number of sets (M) of linear velocity and acceleration to be computed.
23-24	211	Variable code of variable and reference respectively (see variable codes in Item II) for first set of linear data; for example, 21---sled relative to range or 32---hip relative to sled
26-27	211	Same as above for the 2nd set of linear data
29-30	211	Same as above for 3rd set

Repeat the above for each of the M (maximum of 12) sets of linear motion (Format: IX, 211 for each set).

Card Number 3

1-10	F10.0	Time calibration---number of frames per second. May be left blank if film speed is 500 frames per second.
11-20	F10.0	SLED calibration in counts per foot
21-30	F10.0	HIP calibration in counts per foot*
31-40	F10.0	KNEE calibration in counts per foot*
41-50	F10.0	SHOULDER calibration in counts per foot*
51-60	F10.0	ELBOW calibration in counts per foot*
61-70	F10.0	HEAD POINT 1 calibration in counts per foot
71-80	F10.0	HEAD POINT 2 calibration in counts per foot

NOTE: The decimal must be punched in the above data fields unless the data are integer and are right justified.

Card Number 4

1	11	9 in column 1 to indicate the end of test input

NOTE: Cards 1, 2, and 3 are placed in front of the test deck and card 4 is placed after the last frame in the test.

C) The last card in the input deck (before the end of job card) contains the word "END" in columns 1 to 3.

---

*The calibration field for these variables must be zero or blank for ITYPE = 1.

II. VARIABLE CODE IDENTIFICATION

The following code versus variable name list is used throughout the program and card 2 in Item 1-B:

Code	Name
1	Range
2	Sled
3	Hip
4	Knee
5	Shoulder
6	Elbow
7	Head Point 1
8	Head Point 2

III. CARD FORMATS FOR THE TEST INPUT DATA CARDS FOR ITYPE=0

Card Number 1

Column	Format	Data Description
1	I1	Card identification (must be 1).
2-5	I4	Frame number
6-12	I7	X reading in counts for Range data
13-19	I7	Z reading in counts for Range data
20-26	I7	X for Sled
27-33	I7	Z for Sled
34-40	I7	X for Hip
41-47	I7	Z for Hip
48-54	I7	X for Knee
55-61	I7	Z for Knee

Card Number 2

Column	Format	Data Description
1	I1	Card identification (must be 2)
2-5	I4	Frame Number
6-12	I7	X reading in counts for Shoulder data
13-19	I7	Z reading in couts for Shoulder data
20-26	I7	X for Elbow
27-33	I7	Z for Elbow
34-40	I7	X for Head Point 1
41-47	I7	Z for Head Point 1
48-54	I7	X for Head Point 2
55-61	I7	Z for Head Point 2

IV. CARD FORMATS FOR THE TEST INPUT DATA CARDS FOR ITYPE=1

Card Number 1

Column	Format	Data Description
1	I1	Card identification (must be 1).
2-5	I4	Frame number
6-12	I7	X reading in counts for Range data
13-19	I7	Z reading in counts for Range data
20-26	I7	X for Sled
27-33	I7	Z for Sled
34-40	I7	X for Head Point 1
41-47	I7	Z for Head Point 1
48-54	I7	X for Head Point 2
55-61	I7	Z for Head Point 2

NOTE: For ITYPE = 1, only 1 data card is read for each frame.

V. GENERAL COMMENTS

A) If there are any errors in frame or card identification numbers, error statements will be printed at the top of the first output page for the test and all computations after the listing of the input data will be deleted.

B) A maximum of 150 frames (MAXN) will be read for each test. If the test input deck contains more than 150 frames, only the first 150 will be processed. This could be changed by changing MAXN and the array dimensions in the program.

C) If the calibration factor for a variable is missing, flag ICAL(J) is set equal to zero and that variable will be deleted from the analysis.

D) An eleven point quadratic least-square fit is used throughout the program. This could be changed by changing the value of "NP" in the program.

E) The CALCOMP plot abscissa and ordinate scales for the velocity and acceleration data are determined by the plot subroutine (CPLT). The X (abscissa) and Z (ordinate) scales for the variable relative to the sled data are constants. The X-scale ranges from -1.4 to 2.6 feet for IRX = 0 and -3.6 to 0.4 feet for IRX = 1 and Z scale ranges from 0.0 to 4.0 feet. Any displacements outside this range will be set equal to the limiting value.

HYGE Program Setup Cards

1) DATA card, used once per job: Col.1 … Col.10

e.g. 12 FEB 74 (first card in input deck).

2) The following four cards are required for each test:

CARD No. 1 TITLE Card --80 columns of alphanumeric information.

Col.1 … 80

CARD No. 2

TEST No. (1–5) IRX (6) IPR (7) ITYPE (8) IPL (9) IPA (11) IPC (13)

M Sets →

FIRST FRAME LAST FRAME M

2 (26 27) 3 (29 30) 4 (32 33) 5 (35 36) 6 (37 39) 7 (41 42) 8 (44 45) 9 (47 48)

10 (50 51) 11 (53 54) 12 (56 57) (Maximum of 12 sets; usually 3 or 4.)

CARD NO. 3 Calibration Data. (frames/second or counts/foot).

TIME: (1 10) SLED (11 20) HIP * (21 30) KNEE* (31 40)

SHOULDER* (41 50) ELBOW* (51 60) HEAD PT.1 (61 70) HEAD PT.2 (71 80)

* Must be 0 or blank for "ITYPE = 1".

CARD NO. 4

Card No. 4 has a "9" in column 1 (insert after the last frame in the data deck).

3) END Card, used once per job: Punch "END" in columns 1 to 3. (last card in input deck; before "END OF JOB" Card).

V. General Comments:

A) If there are any errors in frame or card identification numbers, error statements will be printed at the top of the first output page for the test and all computations after the listing of the input data will be deleted.

B) A maximum of 150 frames (MAXN) will be read for each test. If the test input deck contains more than 150 frames, only the first 150 will be processed. This could be changed by changing MAXN and the array dimensions in the program.

C) If the calibration factor for a variable is missing, flag ICAL(J) is set equal to zero and that variable will be deleted from the analysis.

D) An eleven point quadratic least square fit is used throughout the program. This could be changed by changing the value of "NP" in the program.

E) The CALCOMP plot abscissa and ordinate scales for the velocity and acceleration data are determined by the plot subroutine (CPLT). The X (abscissa) and Z (ordinate) scales for the variable relative to the sled data are constants. The X scale ranges from -1.4 to 2.6 feet for IRX = 0 and -3.6 to 0.4 feet for IRX = 1 and the Z scale ranges from 0.0 to 4.0 feet. Any displacements outside this range will be set equal to the limiting value.

APPENDIX B

PREPARATION OF DATA FOR INPUT TO HIFPD

STANDARD PRACTICE PROCEDURE

93291-02-1 (Rev. "I", 4 Oct. '76)

This procedure describes the process to be employed in the reduction of photometric data acquired during experimental tests conducted on the Horizontal Impulse Accelerator during the Restraint Systems Dynamics (RSD) investigation.

1. Source Documents

1.1 16 mm motion picture film from cameras mounted:

a. Onboard Lateral view
b. Onboard Oblique view
c. Offborad Lateral view (Backup for "A")
d. Offborad Downtrack view
e. Offboard Overhead view

1.2 Restraint System Dynamic Pretest Anthropometric Measurements data sheet.

1.3 Sled Coordinate System and Camera Scheme, (RSD).

2. Equipment Required

2.1 Producers Service Corp. film digitizer coupled to Teletype w/tape punch.

2.2 Teletype Terminal w/tape reader and telephone coupler.

2.3 IBM Keypunch, Type 029.

3. Editing Requirements

The following sequence of operations shall be followed to determine if all necessary data have been adequately recorded.

3.1 Preview Onboard lateral view film to determine if the following points are observable throughout the test period from first motion of the subject with respect to the seat through return to rest of the subject with respect to the seat. (Refer to Figure B-1).

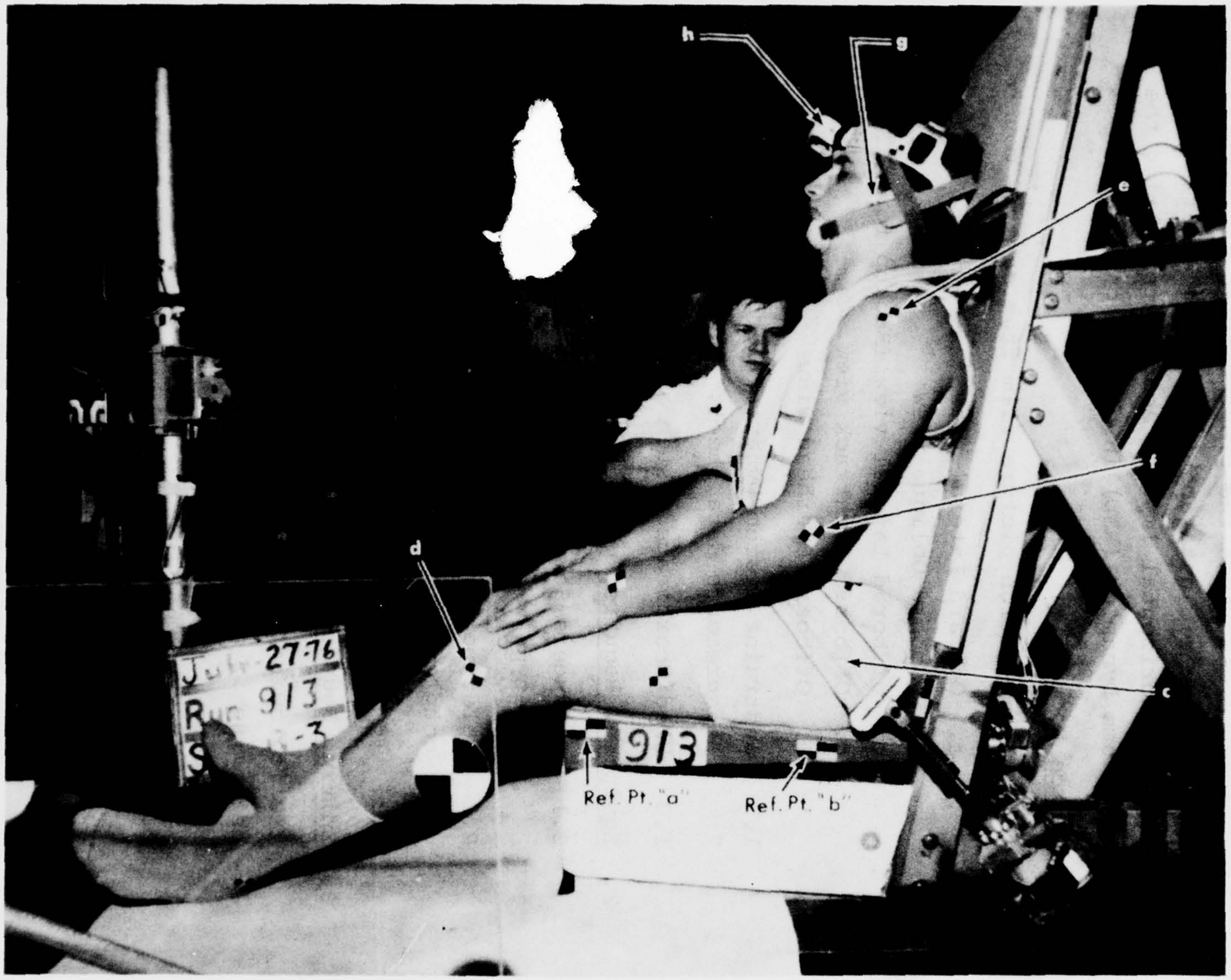


Figure B-1. Anthropometric Points to be Tracked.

a. Forward fiducial, LH side of seat

b. Aft fiducial, LH side of seat

c. Fiducial over hip (<u>or</u> fiducial over iliac creat)

d. Fiducial on knee

e. Fiducial on shoulder

f. Fiducial on elbow

g. Fiducial on jaw hinge (<u>or</u> head mount)

h. Accelerometer at origin of 9TAP accelerometer assembly.

3.2 Determine time - film frame table. Assume time to be 0.000 seconds at upper edge of frame in which the synchronizing flash is first observed, set frame counter to 00000. Interpolate time lapse between this point and next 0.1-second time pulse. (Refer to Figure B-2). Set this value to t_{e1}.

Using the same method, determine the time lapse between the last .01 second time pulse prior to the frame at which the subject returns to rest with respect to the seat (Frame "n" and the start (or top) of this frame. Let this value be t_{e2}.

Count the 0.01 second time intervals between the first pulse after frame 000 and the last pulse prior to frame "n". Multiply the number of intervals by 0.01 seconds and let this value be t_c (calibrated time).

The total elapsed time can now be calculated by summing t_{e1} + t_{e2} + tc.

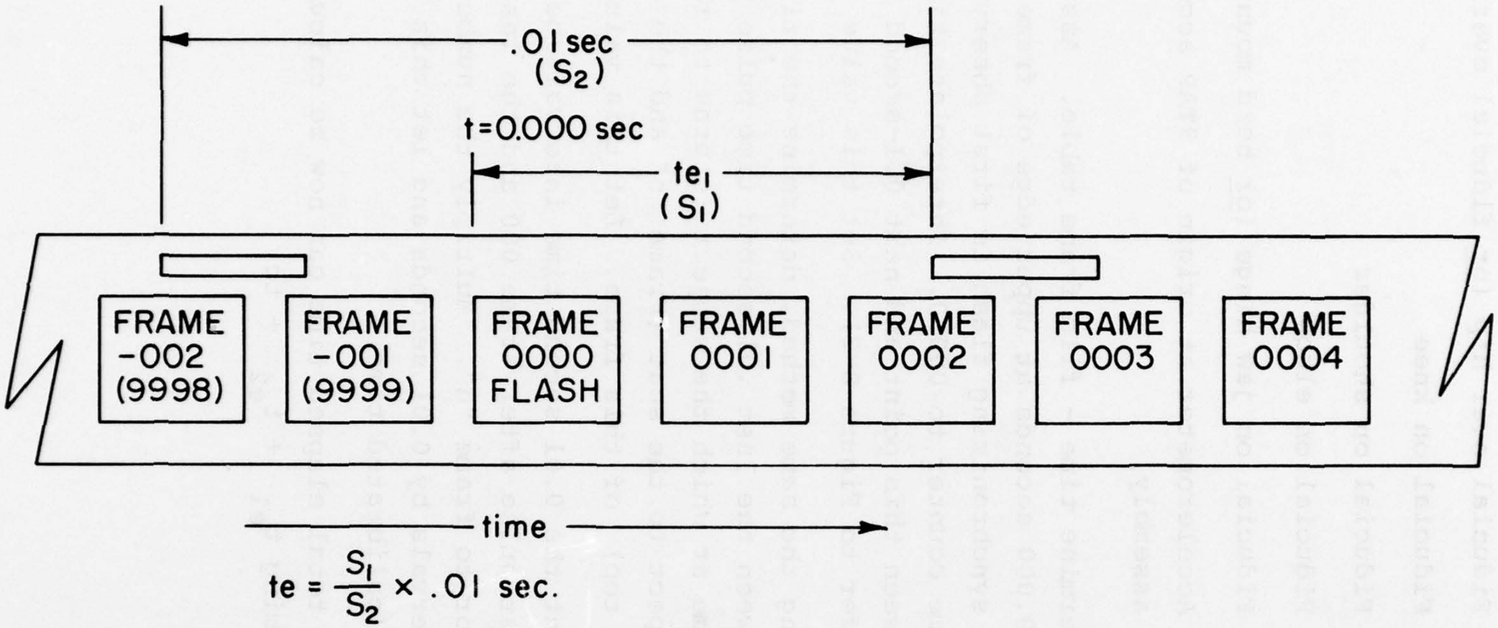


Figure B-2. Time Lapse Determination.

The film speed (or frames per second), which is required as input to the computer program "HIFPD" can now be calculated:

$$\text{Film Speed} = \frac{\text{Frame Count at Frame "n"}}{t_{e1} + t_e + t_{e2}}$$

3.3 Determine Conversion Constants using the "widths" information recorded on the "Restraint Systems Dynamics Pretest Anthropometric Measurements" data sheet, (Figure B-3) the "Sled Coordinate System and Camera Scheme" (Figure B-4) and the PSC digitizer.

Read the coordinate of the fiducials mounted on the side of the seat. Record these on the Calibration Form (Figure B-5).

Calculate resultant scalar dimension between the fiducials on the panel (s_{pi}) and the seat (s_{si}):

$$s_{pi} = (x_{p1} - x_{p2})^2 + (y_{p1} - y_{p2})^2$$

$$s_{si} = (x_{s1} - x_{s2})^2 + (y_{s1} - y_{s2})^2.$$

Calculate conversion constants for these dimensions:

$$f_p = \frac{s_{pi}}{\frac{11.96875}{12}}$$

In like manner:

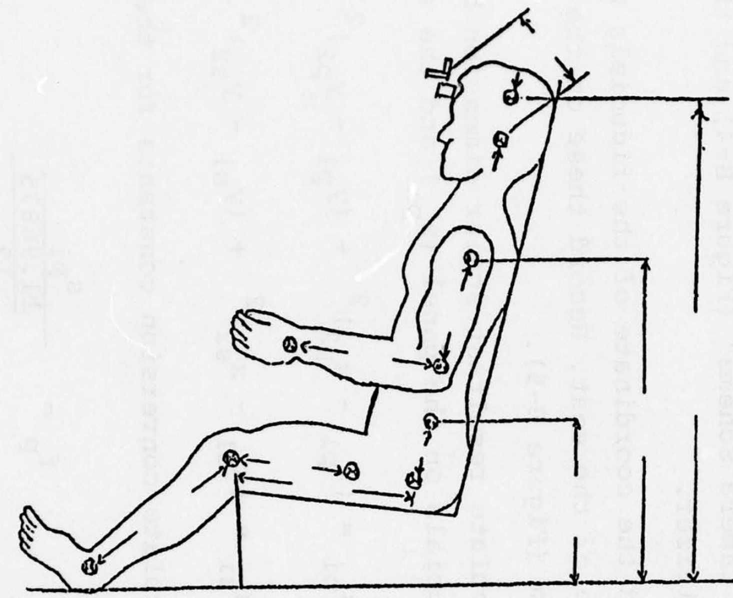
$$f_s = \frac{S_{si}}{\frac{12.0}{12}}$$

Where f_p and f_s are conversion constants in terms of counts/foot.

RESTRAINT SYSTEM DYNAMICS
Pretest Dimensions

Run__________ Subject__________ Seat__________ Velocity__________

Date__________ Restraint__________ Seat Back__________ Acceleration__________



WIDTHS: Jaws__________
Shoulders__________
Elbows__________
Hips__________
Knees__________
Ankles__________

Mid shoulder height__________

Figure B-3. Restraint System Dynamics Pretest Anthropometric Measurements Data Form.

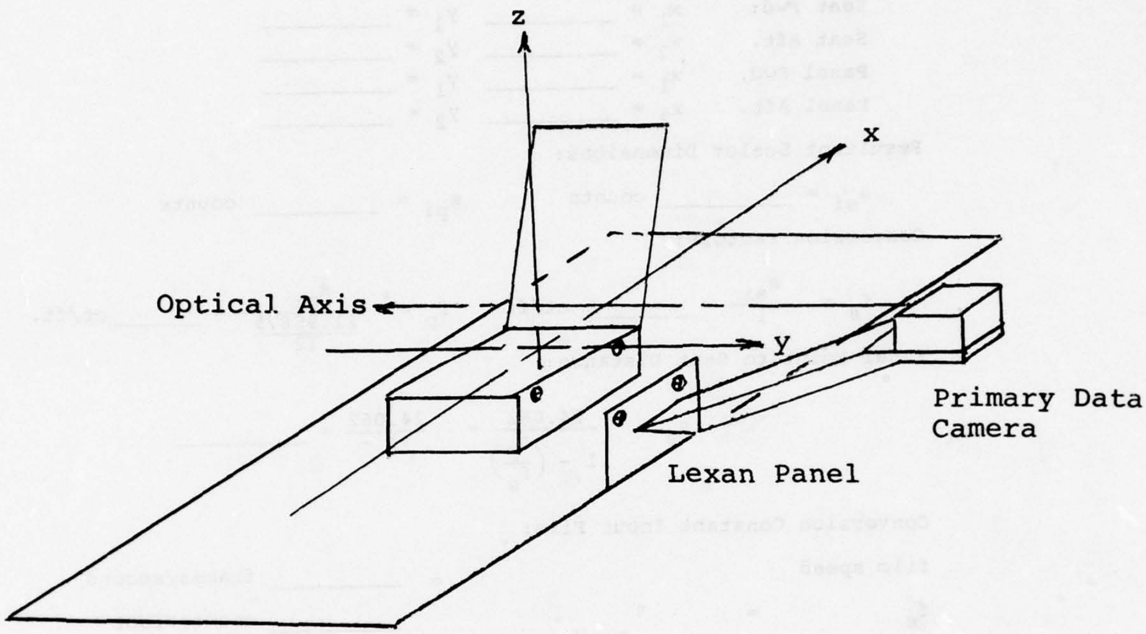


Figure B-4. Sled Coordinate System and Camera Scheme.

RESTRAINT SYSTEM DYNAMICS

Photometric Calibration Form

TEST ________

Fiducial Readings:

Seat Fwd:	x_1 = __________	y_1 = __________
Seat Aft.	x_2 = __________	y_2 = __________
Panel Fwd.	x_1 = __________	y_1 = __________
Panel Aft.	x_2 = __________	y_2 = __________

Resultant Scalar Dimensions:

s_{si} = __________ counts $\qquad$ s_{pi} = __________ counts

Conversion Factors:

$$f_s = \frac{s_{si}}{1} = \_\_\_\_\_\_\_\_ \text{ ct/ft} \qquad f_p = \frac{s_{pi}}{\frac{11.96875}{12}} = \_\_\_\_\_\_\_\_ \text{ct/ft.}$$

Focal Point to Seat Distance:

$$s_s = \frac{24.062}{1 - \left(\frac{f_p}{f_s}\right)} = \frac{24.062}{1 - } = \_\_\_\_\_\_\_\_\_\_$$

Conversion Constant Input File:

film speed		=	__________	frames/second
f_s	=		__________	counts/foot
f_{hip}	=	$\frac{s_s}{s_s + 8 - \_\_\_} \times f_s$ =	__________	counts/foot
f_{knee}	=	$\frac{s_s}{s_s + 8 - \_\_\_} \times f_s$ =	__________	counts/foot
$f_{shoulder}$	=	$\frac{s_s}{s_s + 8 - \_\_\_} \times f_s$ =	__________	counts/foot
f_{elbow}	=	$\frac{s_s}{s_s + 8- \_\_\_} \times f_s$ =	__________	counts/foot
f_{jaw}	=	$\frac{s_s}{s_s + 8- \_\_\_} \times f_s$ =	__________	counts/foot
$f_{accel.}$	=	$\frac{s_s}{s_s + 8- \_\_\_} \times f_s$ =	__________	counts/foot

TEST ______

Figure B-5. Photometric Calibration Form.

The distance from the focal point of the camera to the vertical plane of the edge of the seat can now be calculated (Reference Figures B-6 and B-7).

Since the distance from the transparent panel to the seat edge has been measured to be 24.062-inches and the approximate distance from the focal plane of the camera to the seat edge plane was measured to be 60.625-inches then the distance from the focal point of the lens to the lexan panel, the seat edge, and thus the seat $\mathbb{C}_L$ can be calculated by similar trianges (Reference Figure B-7).

$$\frac{s_p}{s_s} = \frac{s_{si} \times f_p}{s_{si} \times f_s} = \frac{f_p}{f_s}$$

Knowing the measured distance $s_s - s_p$ to be 24.062 inches, thus $s_p = s_s - 24.062$, by substituting we have:

$$\frac{s_s - 24.062}{s_s} = \frac{f_p}{f_s}$$

and

$$\frac{1 - 24.062}{s_s} = \frac{f_p}{f_s}.$$

By subtracting $\frac{f_p}{f_s}$ from both terms and adding $\frac{24.062}{s_s}$ to both terms:

$$1 - \frac{f_p}{f_s} = \frac{24.062}{s_s}$$

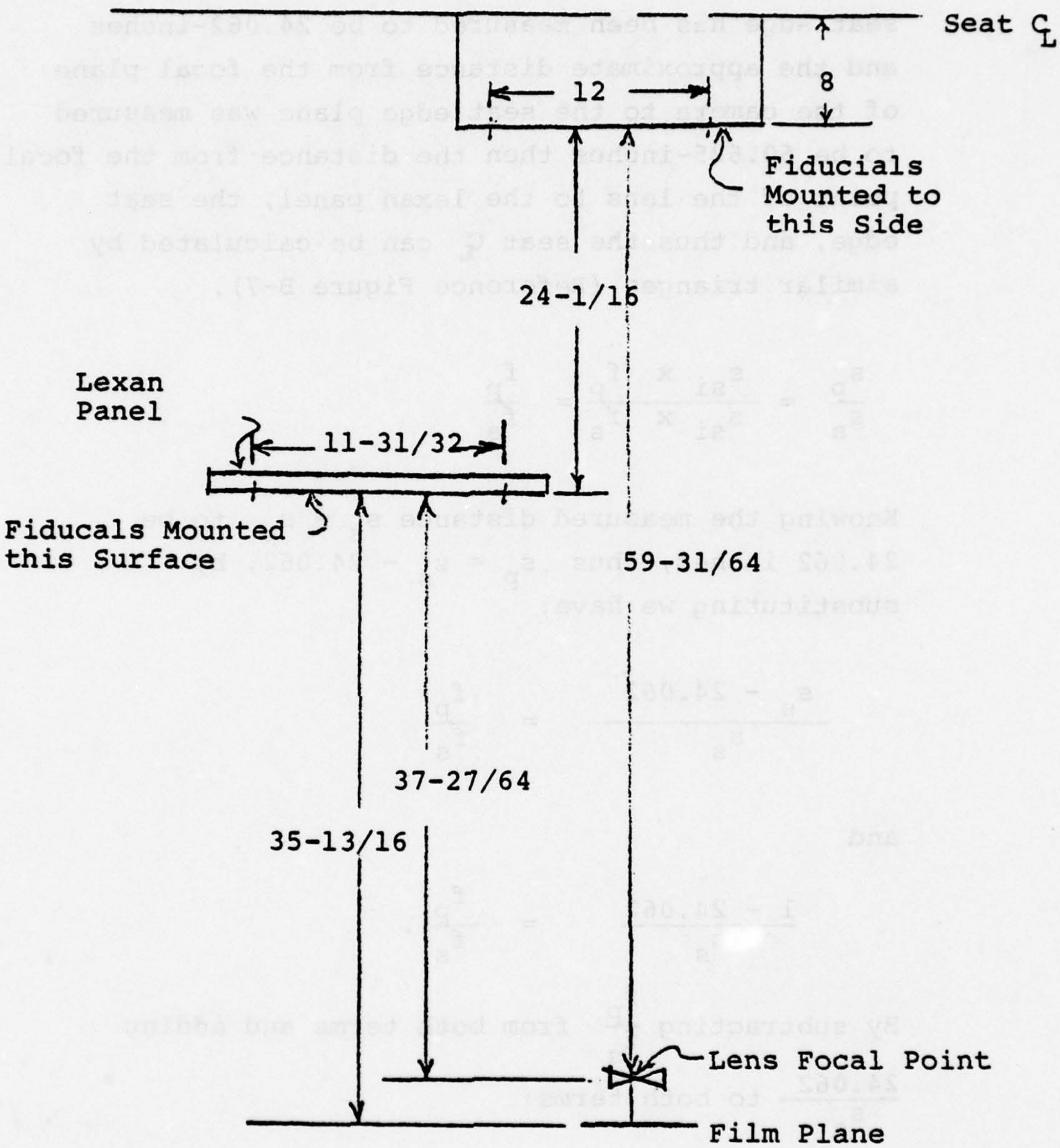


Figure B-6. Schematic of Camera-Reference Fiducials.

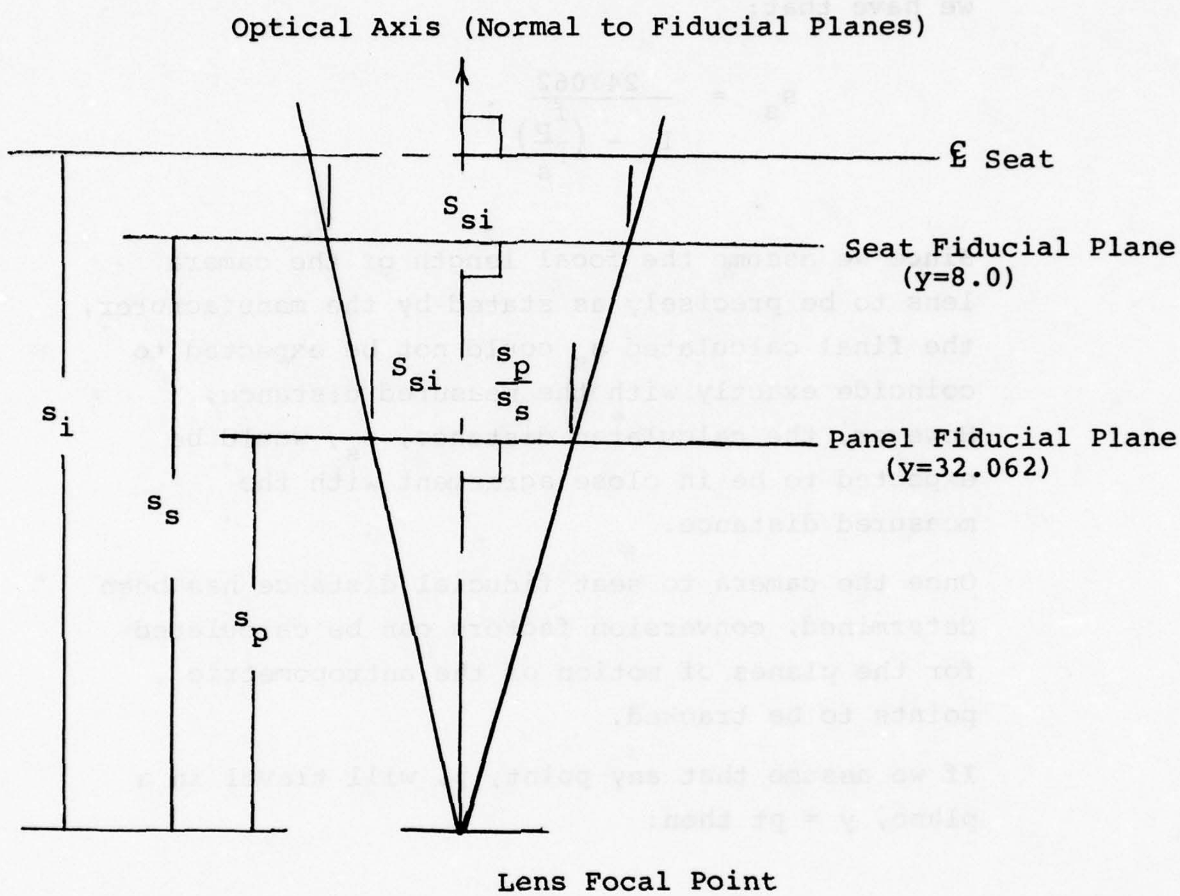


Figure B-7. Photometric Calibration Scheme.

and by multiplying both terms by s_s and by

$$\frac{1}{1 - \frac{f_p}{f_s}}$$

we have that:

$$s_s = \frac{24.062}{1 - (\frac{f_p}{f_s})} .$$

Since we assume the focal length of the camera lens to be precisely as stated by the manufacturer, the final calculated s_s could not be expected to coincide exactly with the measured distance, However, the calculated distance, s_s, would be expected to be in close agreement with the measured distance.

Once the camera to seat fiducial distance has been determined, conversion factors can be calculated for the planes of motion of the antropometric points to be tracked.

If we assume that any point, p, will travel in a plane, y = pt then:

$$\frac{f_{pt}}{f_s} = \frac{s_{pt}}{s_s}$$

where: f_{pt} = conversion factor in plane y = pt (ft/count)

f_s = conversion factor in plane of seat fiducials

s_{pt} = distance along optical axis from focal point to the plane y = pt,

and:

s_s = distance along optical axis from focal point to the plane of the seat fiducals

S_{pt} is determined by:

$$s_{pt} = s_s + 8 \text{ inches} - \frac{w_p}{2}$$

where w_p is the width measurement between the anthropometric points on opposite sides of the subject as noted on the pretest anthropometric measurements form, and s_s = 8 inches = $S_{\text{℄}}$ and the subject is assumed to be seated such that his plane of symmetry coincides with the seat ℄ and that the antropometric points on the left and right sides of the subject are symmetrical about that plane.

All of the preceding calculations are provided for on the photometric calibration form.

4. Film Digitizing

The anthropometric points are tracked by digitizing the "x" and "y" coordinated of each point as projected from each frame during the impact response period. The film must be mounted in such a manner that the subject appears to face the left as viewed on the projection screen. Because of the smoothing routines utilized in the computer processing of the data, care must be taken to start digitizing the data at least fifteen (15) frames before the subject starts to move relative to the seat and it must be continued at least fifteen (15) frames after the subject returns to rest relative to the seat.

Data points are digitized as follows:

Line 1: Frame Number

a. Forward seat reference fiducial; x,y

b. Aft seat reference fiducial; x,y

c. Hip (or iliac crest) fiducial; x,y

d. Knee fiducial; x,y

Line 2: Frame Number

e. Should fiducial; x,y

f. Elbow fiducial; x,y

g. Jaw (or accel. pack mount) fiducial; x,y

h. 9TAP accelerometer reference; x,y

The above data are to be listed on the teletype printer and punched into paper tape on the teletype. Care must be taken to punch a series of rubouts before and after digitizing the data.

APPENDIX C

PROGRAM HIFPD

```
      PROGRAM HIFPD(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7)
      DIMENSION    RES(302),VEL(302),WS(302),WH(302),WS2(302),WH2(302),
     1 HEADL(8),HEADR(8),HEADC(8),DATA(1024),         YNPR(3),YNPL(3)
      COMMON  JD,JR, NN,NP,NC1,NC2,XX(302,6),ZZ(302,6), ICAL(8),
     1          IFR(302),X(302,8),Z(302,8),ID(12),IR(12),ACC(302),
     2ACCG(302),   CAL(8),XD(302),ZD(302),T(302),DI(302),DC(302)
      COMMON /CPLTC/ HEADL,TITLE(10),IRX
      EQUIVALENCE (RES(1),WS(1),DI(1)),(VEL(1),WH(1),DC(1)),(ACC(1),WS2(
     11)),(ACCG(1),WH2(1))
      DATA ENDJ/10HEND       /, YNPR/3HYES,3HYES,3H NO/,YNPL/3HYES,3H NO
     1,3H NO/
      DATA HEADR/9H    RANGE,9H     SLED,9H      HIP,9H     KNEE,
     1 9H SHOULDER,9H    ELBOW,9HHEAD PACK,9H    SNOUT/,
     2  HEADL/5HRANGE,4HSLED,3HHIP,4HKNEE,8HSHOULDER,5HELBOW,9HHEAD PACK
     3, 5HSNOUT/,HEADC/7H  RANGE,7H   SLED,6H   HIP,7H   KNEE,9H SHOULDE
     4R,7H  ELBOW,9HHEAD PACK,7H  SNOUT/
C***********************************************************************
C***********************************************************************
C       HYGE IMPACT FACILITY PHOTOMETRIC DATA ANALYSIS PROGRAM
C***********************************************************************
C
C                       PARAMETER NAME VERSUS ID CODE
C                                CODE           NAME
C
C                                  1            RANGE
C                                  2            SLED
C                                  3            HIP
C                                  4            KNEE
C                                  5            SHOULDER
```

```
C                               6          ELBOW
C                               7          HEAD PACK
C                               8          SNOUT
C
C***********************************************************************
C***********************************************************************
C
C        IRX=0 --- NO X-AXIS CHANGE
C        IRX=1 --- CHANGE POLARITY OF X-AXIS DATA (MULT.BY -1.0)
C
C        ITYPE=0 - READ AND PROCESS ALL 8 PARAMETER.
C        ITYPE=1 - READ AND PROCESS ONLY PARAMETERS 1, 2, 7 AND 8.
C
C        IPR<1 --- PRINT RAW DATA IN COUNTS
C
C        IPL=0 --- PRINT AND PLOT LINEAR VEL AND ACCEL DATA
C        IPL=1 --- PRINT LINEAR VEL AND ACCEL DATA
C        IPL=2 --- OMIT LINEAR VEL AND ACCEL DATA
C
C        IPA=0 --- PRINT AND PLOT ANGULAR VEL AND ACCEL DATA
C        IPA=1 --- PRINT ANGULAR VEL AND ACCEL DATA
C        IPA=2 --- OMIT  ANGULAR VEL AND ACCEL DATA
C
C        IPC=0 --- PRINT AND PLOT PARAMETER VERSUS SLED DATA
C        IPC=1 --- PRINT PARAMETER VERSUS SLED DATA
C        IPC=2 --- OMIT  PARAMETER VERSUS SLED DATA
C
C        DISPLACEMENT, VEL AND ACCEL DATA ARE COMPUTED FOR 'M' SETS OF
C        DATA.  ID(I) AND IR(I) CONTAIN THE 'M' SETS OF PARAMETER CODES
C        FOR PARAMETER AND REFERENCE RESPECTIVELY.
C
C        ID(I) --- CONTAINS PARAMETER IDENT CODE
C        IR(I) --- CONTAINS REFERENCE IDENT CODE
```

```
C
C       TITLE(1) --- CONTAINS THE DATE
C       TITLE(2) --- CONTAINS THE TEST NUMBER
C       TITLE(3) ---> TITLE(10) --- CONTAIN AN 80 CHARACTER PAGE TITLE.
C
C       CAL(J) --- CONTAINS THE CALIBRATION FACTORS FOR PARAMETERS 2
C                  THROUGH 8.
C
C       JD --- FRAME NUMBER OF FIRST FRAME PLOTTED ON PARAMETER VERSUS
C              SLED PLOT. (REDEFINED AFTER INPUT)
C       JR --- FRAME NUMBER OF LAST  FRAME PLOTTED ON PARAMETER VERSUS
C              SLED PLOT. (REDEFINED AFTER INPUT)
C
      CALL PLOTS(DATA,1024,7)
C  MAXN IS THE MAXIMUM NUMBER OF FRAMES WHICH CAN BE PROCESSED WITH
C  ABOVE ARRAY DIMENSIONS.
      MAXN=300
      C1=-1.0E10
      CAL(1)=0.0
      ICAL(1)=1
      PI=3.1415927
      PI2=2.0*PI
      PI34=3.0*PI/4.0
C  NP IS THE NUMBER OF POINTS USED IN THE QUADRATIC LEAST SQUARE FIT.
      NP=11
C
C  READ TEST SETUP CARDS.
C  TITLE(1) CONTAINS THE DATE.
C
      READ(5,1010)TITLE(1)
    5 READ(5,1010)(TITLE(I),I=3,10)
      IF (TITLE(3) .EQ. ENDJ) GO TO 999
C     READ(5,1005) NP1,NP2,JD,JR
```

```
C     IF (NP1 .LT. 3) NP1=11
C     IF (NP2 .LT. 3) NP2=11
C
C  TITLE(2) CONTAINS THE TEST NUMBER.
C
      READ(5,1030) TITLE(2),IRX,IPR,ITYPE,IPL,IPA,IPC,JD,JR,M,
     1 (ID(I),IR(I),I=1,M)
      READ(5,1020) DT,(CAL(J),J=2,8)
      IF (JD .LT. 1) JD=1
      IF (JR .LT. 1) JR=999
      WRITE(6,2500) TITLE,NP
      IF (IRX) 480,480,490
  480 IRX=0
      GO TO 495
  490 IRX=1
  495 IF (IPR) 500,500,505
  500 IPR=0
      GO TO 510
  505 IPR=1
  510 IF (IPL-1) 515,525,520
  515 IPL=0
      GO TO 525
  520 IPL=2
  525 IF (IPA-1) 530,540,535
  530 IPA=0
      GO TO 540
  535 IPA=2
  540 IF (IPC-1) 545,560,550
  545 IPC=0
      GO TO 560
  550 IPC=2
  560 I=1
      IFLAG=0
```

```
      NC1=1
      NC2=999
      IFRD=-100
      IF(DT) 565,565,570
  565 DT=500.0
  570 IF (ITYPE) 575,575,580
  575 ITYPE=0
      J1=3
      GO TO 10
  580 ITYPE=1
      J1=7
  585 READ(5,1000) ICD,IFR(I),(X(I,J),Z(I,J),J=1,2),(X(I,J),Z(I,J),J=7,8
     1)
      DO 590 J=3,6
      X(I,J)=0.0
  590 Z(I,J)=0.0
      IF (ICD-1) 595,595,100
  595 IF (IFR(I)-IFRD) 600,600,610
  600 WRITE(6,2410) IFR(I)
      IFLAG=1
  610 IFRD=IFR(I)
      GO TO 40
C
C  FROM HERE TO LABEL 115: READ A MAXIMUM OF 'MAXN' FRAMES OF INPUT DATA
C
   10 READ(5,1000) ICD,IFR(I),(X(I,J),Z(I,J),J=1,4)
C  FOLLOWING CARD CHANGED TO INPUT PAPER TAPE DATA:
      IF (ICD-1)  15,15,100
C     IF (ICD-1) 100,15,100
   15 IF (IFR(I)-IFRD) 20,20,25
   20 WRITE(6,2410) IFR(I)
      IFLAG=1
   25 READ(5,1000) ICD,IFRD,(X(I,J),Z(I,J),J=5,8)
```

```
C  FOLLOWING CARD CHANGED TO INPUT PAPER TAPE DATA:
      IF (ICD-2)  30,30,70
C     IF (ICD-2)  70,30,70
   30 IF (IFR(I)-IFRD) 35,40,35
   35 WRITE(6,2400) IFR(I),IFRD
      IFLAG=1
   40 T(I)=FLOAT(IFR(I))/DT
      IF (IFR(I) .EQ. JD) NC1=I
      IF (IFR(I) .EQ. JR) NC2=I
      IF (I-MAXN) 50,50,60
   50 I=I+1
      IF (ITYPE) 10,10,585
   60 WRITE(6,2840) MAXN,IFR(I)
      IF (ITYPE) 10,10,585
   70 WRITE(6,2000) ICD,IFRD
      IFLAG=1
      GO TO 10
  100 IF (ICD-9) 110,115,110
  110 WRITE(6,2000) ICD,IFR(I)
      IFLAG=1
      IF (ITYPE) 10,10,585
  115 N=I-1
      DTT=(T(N)-T(1))/FLOAT(N-1)
      IF (IRX) 118,118,116
  116 DO 117 I=1,N
      DO 117 J=1,8
  117 X(I,J)=-X(I,J)
C
C  PRINT TEST PARAMETER SUMMARY PAGE.
C
  118 WRITE(6,2100) (I,I=1,M)
      WRITE(6,2110) TITLE(2),N,DT,IRX,ITYPE,IPR,IPL,IPA,IPC,M,
     1 (ID(I).IR(I).I=1.M)
```

```
      WRITE(6,2120)  (HEADL(I),I=2,8)
      WRITE(6,2130)  (CAL(I),I=2,8)
      WRITE(6,2140)  DTT
      WRITE(6,2150)  N
      WRITE(6,2155)   YNPL(2-IRX)
      WRITE(6,2160)   YNPR(IPR+1)
      WRITE(6,2190)  YNPR(IPL+1),YNPL(IPL+1)
      WRITE(6,2180)  YNPR(IPA+1),YNPL(IPA+1)
      WRITE(6,2170)  YNPR(IPC+1),YNPL(IPC+1)
      DO 130  J=2,8
      IF (ABS(CAL(J))) 120,125,120
  120 CAL(J)=1.0/CAL(J)
      ICAL(J)=1
      GO TO 130
  125 ICAL(J)=0
      WRITE(6,2820) HEADL(J)
  130 CONTINUE
      WRITE(6,2570)
      IF (M) 137,137,132
  132 DO 135 K=1,M
      JD=ID(K)
      JR=IR(K)
      IF (ICAL(JD) .LT. 1 .OR. ICAL(JR) .LT. 1) GO TO 135
      WRITE(6,2210) K,HEADL(JD),HEADL(JR)
  135 CONTINUE
  137 IF (IPR) 140,140,165
C
C  PRINT RAW INPUT DATA IN COUNTS.
C
  140 WRITE(6,2500) TITLE,NP
      WRITE(6,2550)
      WRITE(6,2560) HEADC
      DO 145 I=1,N
```

```
  145 WRITE(6,2580) IFR(I),(X(I,J),Z(I,J),J=1,8)
      WRITE(6,2500) TITLE,NP
      WRITE(6,2552)
      WRITE(6,2560) HEADC
C
C  COMPUTE AND PRINT FRAME TO FRAME DIFFERENCES IN COUNTS
C
      IF (ITYPE) 148,148,146
  146 DO 147 J=3,6
      XD(J)=0.0
  147 XD(J)=0.0
  148 DO 160 I=2,N
      XD(1)=X(I,1)-X(I-1,1)
      ZD(1)=Z(I,1)-Z(I-1,1)
      XD(2)=X(I,2)-X(I-1,2)-XD(1)
      ZD(2)=Z(I,2)-Z(I-1,2)-ZD(1)
      DO 150 J=J1,8
      XD(J)=X(I,J)-X(I-1,J)-XD(1)
  150 ZD(J)=Z(I,J)-Z(I-1,J)-ZD(1)
      WRITE(6,2580) IFR(I),(XD(J),ZD(J),J=1,8)
  160 CONTINUE
C  CONVERT DATA FROM COUNTS TO FEET.
  165 IF (IFLAG) 170,170,167
  167 WRITE(6,2500) TITLE,NP
      WRITE(6,2830)
      GO TO 5
  170 DO 185 I=1,N
C
C  H1 AND H2 ADJUST DATA FOR SHIFT IN RANGE REFERENCE READING.
C
      H1=X(I,1)-X(1,1)
      H2=Z(I,1)-Z(1,1)
      X(I,2)=(X(I.2)-H1)*CAL(2)
```

```
      Z(I,2)=(Z(I,2)-H2)*CAL(2)
      DO 180 J=J1,8
      X(I,J)=(X(I,J)-H1)*CAL(J)
  180 Z(I,J)=(Z(I,J)-H2)*CAL(J)
  185 CONTINUE
C     DO 800 NP=NP1,NP2,2
      N1=(NP-1)/2+1
      N2=N-N1+1
      N3=3*N1-2
      N4=N-N3+1
      NN=N2-N1+1
      IF (IPC+IPA-4) 700,800,800
C
C*********** COMPUTE PARAMETER VERSUS SLED DISPLACEMENTS.
C
  700 DO 725 J=3,8
      JJ=J-2
      IF (ICAL(J)) 715,715,705
  705 DO 710 I=1,N
      XD(I)=X(I,J)-X(I,2)
  710 ZD(I)=Z(I,J)-Z(I,2)
      I=1
      CALL SM(T,XD,XX(I,JJ),N,NP)
      CALL SM(T,ZD,ZZ(I,JJ),N,NP)
      GO TO 725
  715 DO 720 I=N1,N2
      XX(I,JJ)=0.0
  720 ZZ(I,JJ)=0.0
  725 CONTINUE
      IF (IPC-1) 728,728,743
  728 LINE=60
      DO 740 I=N1,N2
      IF (LINE-50) 735,730,730
```

```
  730 WRITE(6,2500) TITLE,NP
      WRITE(6,2555)
      WRITE(6,2565)    (HEADC(J),J=3,8)
      LINE= 0
C  PRINT PARAMETER VERSUS SLED DATA.
  735 WRITE(6,2585) IFR(I),T(I),(XX(I,JJ),ZZ(I,JJ),JJ=1,6)
      LINE=LINE+1
  740 CONTINUE
      IF (IPC) 742,742,743
  742 IF (NC1 .LT. N1) NC1=N1
      IF (NC2 .GT. N2) NC2=N2
      NN=NC2-NC1+1
      IP=1
C  PLOT PARAMETER VERSUS SLED DATA.
      CALL CPLT(T,DI,DC,IP)
      WRITE(6,2595) IFR(NC1),IFR(NC2)
  743 IF (IPA-2) 745,800,800
C************************
C  COMPUTE ANGULAR VELOCITY AND ACCELERATION;  HERE TO LABER 775.
C************************
  745 XD(N1-1)=PI
      ZD(N1-1)=PI
      IF (ICAL(3)+ICAL(5)-2) 756,750,750
  750 DO 755 I=N1,N2
      H1=ZZ(I,3)-ZZ(I,1)
      H2=XX(I,3)-XX(I,1)
C  SHOULDER - HIP ANGLE
      XD(I)=ATAN2(H1,H2)
      IF (XD(I) .LT. 0.0) XD(I)=XD(I)+PI2
      IF (ABS(XD(I)-XD(I-1)) .GT. PI34) XD(I)=XD(I)+PI2
  755 CONTINUE
      CALL DERIV1(T,XD,WS,N,NP,1)
      CALL DERIV1(T.WS.WS2.N.NP.2)
```

```
      GO TO 758
  756 DO 757 I=N1,N2
      XD(I)=0.0
      WS(I)=0.0
  757 WS2(I)=0.0
  758 IF (ICAL(7)+ICAL(8)-2) 762,759,759
  759 DO 760 I=N1,N2
      H1=ZZ(I,5)-ZZ(I,6)
      H2=XX(I,5)-XX(I,6)
C  HEAD PACK - SNOUT ANGLE
      ZD(I)=ATAN2(H1,H2)
      IF (ZD(I) .LT. 0.0) ZD(I)=ZD(I)+PI2
      IF (ABS(ZD(I)-ZD(I-1)) .GT. PI34) ZD(I)=ZD(I)+PI2
  760 CONTINUE
      CALL DERIV1(T,ZD,WH,N,NP,1)
      CALL DERIV1(T,WH,WH2,N,NP,2)
      GO TO 768
  762 DO 764 I=N1,N2
      ZD(I)=0.0
      WH(I)=0.0
  764 WH2(I)=0.0
  768 LINE=60
      DO 775 I=N3,N4
      IF (LINE-50) 772,770,770
  770 WRITE(6,2500) TITLE,NP
      WRITE(6,2551)
      WRITE(6,2520)
      LINE= 0
C  PRINT   ANGULAR VELOCITY AND ACCELERATION.
  772 WRITE(6,2590) IFR(I),T(I),XD(I),WS(I),WS2(I),ZD(I),WH(I),WH2(I)
      LINE=LINE+1
  775 CONTINUE
      IF (IPA) 780,780,800
```

```
  780 IP=2
      NN=N4-N3+1
      JD=5
      JR=3
      IF (ICAL(3)+ICAL(5)-2) 790,785,785
C  PLOT ANGULAR VELOCITY AND ACCELERATION DATA.
  785 CALL CPLT(T(N3),WS(N3),WS2(N3),IP)
  790 JD=7
      JR=8
      IF (ICAL(7)+ICAL(8)-2) 800,795,795
  795 CALL CPLT(T(N3),WH(N3),WH2(N3),IP)
  800 CONTINUE
      IF (M .LT. 1 .OR. IPL .EQ. 2) GO TO 5
      DO 200 J=2,8
      IF (ICAL(J)) 200,200,190
  190 DO 195 I=2,N
      X(I,J)= X(I,J)-X(1,J)
  195 Z(I,J)= Z(I,J)-Z(1,J)
      X(1,J)= 0.0
      Z(1,J)= 0.0
  200 CONTINUE
      IP=3
C 202 DO 410 NP=NP1,NP2,2
C     N1=(NP-1)/2+1
C     N2=N-N1+1
C     N3=3*N1-2
C     N4=N-N3+1
      NN=N4-N3+1
C
C************************
C  COMPUTE LINEAR VELOCITY AND ACCEL DATA FOR PARAMETER ID(K) WITH
C  RESPECT TO IR(K); HERE TO LABEL 400.
C************************
```

```
C
      DO 400 K=1,M
      JD=ID(K)
      IF (JD .LE. 1) GO TO 390
      JR=IR(K)
      IF (JR .LT. 1) GO TO 395
      IF (ICAL(JD) .LT. 1 .OR. ICAL(JR) .LT. 1) GO TO 400
      XMP=C1
      ZMP=C1
      RM= C1
      XMN=-C1
      ZMN=-C1
      DO 212 I=1,N
      IF (JR-1) 205,205,210
  205 DI(I)=X(I,JD)
      DC(I)=Z(I,JD)
      GO TO 212
  210 DI(I)=X(I,JD)-X(I,JR)
      DC(I)=Z(I,JD)-Z(I,JR)
  212 CONTINUE
      CALL SM(T,DI,XD,N,NP)
      CALL SM(T,DC,ZD,N,NP)
C
C  COMPUTE MAXIMUM X, Z AND RESULTANT DISPLACEMENT.
C
      DO 260 I=N1,N2
      RES(I)=SQRT(XD(I)*XD(I)+ZD(I)*ZD(I))
      IF (XD(I)-XMP) 220,220,215
  215 XMP=XD(I)
      TXMP=T(I)
      GO TO 230
  220 IF (XD(I)-XMN) 225,230,230
  225 XMN=XD(I)
```

```
      TXMN=T(I)
  230 IF (ZD(I)-ZMP) 240,240,235
  235 ZMP=ZD(I)
      TZMP=T(I)
      GO TO 250
  240 IF (ZD(I)-ZMN) 245,245,250
  245 ZMN=ZD(I)
      TZMN=T(I)
  250 IF (RES(I)-RM) 260,260,255
  255 RM=RES(I)
      TRM= T(I)
  260 CONTINUE
C  COMPUTE LINEAR VELOCITY.
      CALL DERIV1(T,RES,VEL,N,NP,1)
C  COMPUTE LINEAR ACCELERATION DATA.
      CALL DERIV1(T,VEL,ACC,N,NP,2)
      LINE=60
      DO 280 I=N3,N4
      IF (LINE-50) 275,270,270
  270 WRITE(6,2500) TITLE,NP
      WRITE(6,2200) HEADR(JD),HEADL(JR)
      WRITE(6,2510)
      LINE= 0
C  PRINT LINEAR DISPL, VEL AND ACCEL DATA.
  275 ACCG(I)=ACC(I)/32.2
      WRITE(6,2600) IFR(I),T(I),XD(I),ZD(I),RES(I),VEL(I),ACC(I),ACCG(I)
      LINE=LINE+1
  280 CONTINUE
      IF (LINE-40)  330,330,320
  320 WRITE(6,2500) TITLE,NP
      WRITE(6,2200) HEADR(JD),HEADL(JR)
  330 WRITE(6,2700) XMP,TXMP
      WRITE(6.2710) XMN.TXMN
```

```
      WRITE(6,2720)ZMP,TZMP
      WRITE(6,2730) ZMN,TZMN
      WRITE(6,2740) RM,TRM
C
C  PLOT LINEAR VELOCITY AND ACCELERATION DATA.
C
  350 IF (IPL) 360,360,400
  360 CALL CPLT(T(N3),VEL(N3),ACCG(N3),IP)
      GO TO 400
  390 WRITE(6,2500) TITLE,NP
      WRITE(6,2800) K
      GO TO 400
  395 WRITE(6,2500) TITLE,NP
      WRITE(6,2810) K
  400 CONTINUE
C 410 CONTINUE
      GO TO 5
  999 WRITE(6,2900)
      CALL PLOTE
      STOP
C  FOLLOWING CARD CHANGED TO INPUT PAPER TAPE DATA:
 1000 FORMAT(I1,I4,8F7.0)
C1000 FORMAT(I1,I5,8F6.0)
 1010 FORMAT(8A10)
 1020 FORMAT(8F10.0)
 1030 FORMAT(A5,4I1,2I2,2I3,I2,12(I2,I1))
 2000 FORMAT(/ 4X,*ERROR IN CARD IDENTIFICATION NUMBER; CARD ID=*,I2,
     1 *; FRAME NUMBER =*,I4)
 2100 FORMAT(// 4X,*TEST     N       DT       IRX  ITYPE  IPR   IPL   IPA
     1IPC    M   SETS:*,12I4)
 2110 FORMAT( 3X,A5,I6,F10.3,I4,5I6,I5,7X,12(I3,I1))
 2120 FORMAT(// 36X,7(A10,2X))
 2130 FORMAT(  4X,*CALIB DATA IN COUNTS PER FOOT:*,F9.3,6F12.3)
```

```
2140 FORMAT(/ 4X,*AVERAGE TIME INCREMENT BETWEEN POINTS:*,F10.5)
2150 FORMAT(/4X,*NUMBER OF FRAMES READ: *,I4,* FRAMES*)
2155 FORMAT(/4X,*REVERSE POLARITY OF X-AXIS DATA (MULT. BY -1.0): *,A3)
2160 FORMAT(/4X,*PRINT LISTING OF INPUT DATA IN COUNTS:  *,A3)
2170 FORMAT(/4X,*PARAMETERS RELATIVE TO SLED DISPLACEMENTS:   PRINT? *,
    1A3,4X,*PLOT? *,A3)
2180 FORMAT(/4X,*ANGULAR VELOCITY  AND  ACCELERATION DATA:    PRINT? *,
    1A3,4X,*PLOT? *,A3)
2190 FORMAT(/4X,*LINEAR  VELOCITY  AND  ACCELERATION DATA:    PRINT? *,
    1A3,4X,*PLOT? *,A3)
2200 FORMAT(// 31X,A9,* MOTION RELATIVE TO THE *,A9)
2210 FORMAT(/10X,I2,*) *,A9,* MOTION RELATIVE TO THE *,A9)
2400 FORMAT(/ 4X,*ERROR IN FRAME NUMBERS; FRAME NUMBER ON CARD 1 =*,I4,
    1  * FRAME NUMBER ON CARD 2 =*,I4)
2410 FORMAT(/ 4X,*FRAME NUMBER IS NOT INCREASING; CHECK FRAME COUNT FOR
    1 CARD 1, FRAME= *,I5)
2500 FORMAT(1H1,3X,*DATE: *,A10,20X,*TEST NUMBER: *,A5/
    1/ 4X,8A10,5X,I2,* POINT QUADRATIC FIT*)
2510 FORMAT(/  32X,*DISPLACEMENT*,15X,*VELOCITY *,2(5X,*ACCELERATION*)/
    A  4X,*FRAME*,
    1   4X,*TIME*,8X,*X*,10X,*Z  *,2(5X,*RESULTANT*),2(8X,*RESULTANT*)/
    B  4X,* NO. *,
    2  4X,*(SEC)*,2(5X,*(FEET)*),6X,*(FEET)*,7X,*(FT/SEC)*,7X,*(FT/SEC
    3SQ)*,10X,*(G)*)
2520 FORMAT(// 29X,*SHOULDER - HIP*,23X,*HEAD PACK - SNOUT*/
    1  * FRAME      TIME*, 2( 7X,*THETA*, 8X,*W*,10X,*W-ACC*, 4X)/
    2  *  NO.      (SEC)*, 2(4X,*(RADIANS)  (RAD/SEC)  (RAD/SEC SQ) *))
2550 FORMAT(//4X,*THE FOLLOWING IS A LISTING OF THE INPUT DATA IN COUNT
    1S:*)
2551 FORMAT(//4X,*THE FOLLOWING IS A LISTING OF THE ANGULAR MOTION OF T
    1HE HEAD AND SHOULDER:*)
2552 FORMAT(//4X,*THE FOLLOWING IS A LISTING OF D(I)-DR(I)-D(I-1)+DR(I-
    11) IN COUNTS:*)
```

```
2555 FORMAT(//4X,*THE FOLLOWING IS A LISTING OF PARAMETER - SLED DISPLA
   1CEMENT IN FEET:*)
2560 FORMAT(//   * FRAME *, 8(6X,A10)/  2X,*NO.*, 8(8X,*X*,6X,*Z*))
2565 FORMAT(//   * FRAME      TIME *,6( 7X,A10)/
   1   *  NO.       (SEC)*, 6( 7X,*X*,6X,*Z  *))
2570 FORMAT(//4X,*LINEAR DISPLACEMENT, VELOCITY AND ACCELERATION DATA W
   1ILL BE COMPUTED FOR THE FOLLOWING:*)
2580 FORMAT(1X,I4,2X,8(F9.0,F7.0))
2585 FORMAT(1X,I4,F11.5,6(F10.3,F7.3))
2590 FORMAT(1X,I4,F11.5,2(F10.3,F11.3,F13.3,6X))
2595 FORMAT(//4X,*THE ABOVE DATA WAS PLOTTED (X VERSUS Z) FOR FRAME NUM
   1BER*,I4,* TO FRAME NUMBER*,I4)
2600 FORMAT(4X,I4, F11.5,F10.3,F11.3,F12.3,F15.3,F16.3,F17.3)
2700 FORMAT(/  4X,*MAXIMUM POSITIVE X DISPLACEMENT=*,F8.3,  * AT TIME *
   1, F8.5)
2710 FORMAT(/  4X,*MAXIMUM NEGATIVE X DISPLACEMENT=*,F8.3,  * AT TIME *
   1, F8.5)
2720 FORMAT(/  4X,*MAXIMUM POSITIVE Z DISPLACEMENT=*,F8.3,  * AT TIME *
   1, F8.5)
2730 FORMAT(/  4X,*MAXIMUM NEGATIVE Z DISPLACEMENT=*,F8.3,  * AT TIME *
   1, F8.5)
2740 FORMAT(/  4X,*MAXIMUM RESULTANT  DISPLACEMENT=*,F8.3,  * AT TIME *
   1, F8.5)
2800 FORMAT(///4X,  *OMIT COMPUTATIONS FOR SET*,I3/  4X,*THE PROGRAM IS
   1 NOT DESIGNED TO COMPUTE RANGE DISPLACEMENT, VELOCITY AND ACCELERA
   2TION.*/  4X,*DATA PARAMETER CODE IS LESS THAN OR EQUAL TO 1*)
2810 FORMAT(///4X,  *OMIT COMPUTATIONS FOR SET*,I3/
   1    4X,*REFERENCE PARAMETER CODE IS LESS THAN 1*)
2820 FORMAT(/ 4X,*CALIBRATION FACTOR IS 0.0 THUS COMPUTATIONS WILL BE O
   1MITTED FOR THE FOLLOWING PARAMETER: *,A10)
2830 FORMAT(//1X,134(1H*)//4X,  *OMIT THE REMAINDER OF THE COMPUTATIONS
   1 FOR THIS TEST BECAUSE OF INPUT CARD PROBLEMS.*/
   2 4X,*SEE ERROR STATEMENTS AT THE BEGINNING OF THE OUTPUT FOR THIS
```

```
     3TESI*// 1X,134(1H*))
2840 FORMAT(/4X,*NUMBER OF FRAMES IS >*,I4,*;  OMIT DATA FOR FRAME NUMB
    1ER:*,I4)
2900 FORMAT(*1  END OF JOB*)
     END
     SUBROUTINE CPLT(T,Y,Z,IP)
     DIMENSION X(302),T(1),Y(1),Z(1)
     COMMON  JD,JR,  N,NP,I1,I2,XX(302,6),ZZ(302,6),ICAL(8)
     COMMON /CPLTC/ HEADL(8),DATE,TEST,TITLE(8),IRX
C  IP=1 --- COMPOSITE PLOT OF PARAMETER VERSUS SLED DATA
C  IP=2 --- PLOT OF ANGULAR VEL AND ACCEL
C  IP=3 --- PLOT OF VEL AND ACCEL
C  SXMAX IS THE MAXIMUM LENGTH OF THE TIME SCALE IN INCHES.
     SXMAX=32.0
     SY=10.0
     DX=0.02
     N1=N+1
     N2=N+2
     IF (IP-2) 300,5,5
   5 DO  10 J=1,N
  10 X(J)=T(J)
     X(N1)=FLOAT(IFIX(X(1)*100.01))*0.01
     X(N2)=DX
     SX=   FLOAT(IFIX((X(N)-X(N1))/DX)+1)
     IF (SX .GT. SXMAX) SX= SXMAX
     CALL AXIS(0.0,0.0,12HTIME IN SEC.,-12,SX,0.0,X(N1),DX)
     IF (IP .EQ. 2) GO TO 400
     AMX=-1.0E10
     AMN= 1.0E10
     DO  15 J=1,N
     AMX=AMAX1(AMX,Y(J))
     AMX=AMAX1(AMX,Z(J))
     AMN=AMIN1(AMN.Y(J))
```

```
      AMN=AMIN1(AMN,Z(J))
   15 CONTINUE
      IF (AMN) 30,20,20
   20 AMN=0.0
      GO TO 40
   30 AMN=FLOAT(IFIX(AMN/10.0)-1)*10.0
   40 AMX=FLOAT(IFIX(AMX/10.0)+1)*10.0
      DYY=(AMX-AMN)/SY
      IF (DYY-10.0) 50,50,60
   50 DY=10.0
      YMIN=AMN
      GO TO 100
   60 IF (DYY-20.0) 70,70,80
   70 DY=20.0
      GO TO 90
   80 DY=30.0
   90 YMIN=FLOAT(IFIX(AMN/DY)   )*DY
      IF (YMIN .GT. AMN) YMIN=YMIN-DY
  100 YMAX=SY*DY+YMIN
      IF (AMX .GT. YMAX) YMIN=YMIN+DY
      Y(N1)=YMIN
      Z(N1)=YMIN
      Y(N2)=DY
      Z(N2)=DY
      CALL AXIS(0.0,0.0,26HVEL IN FT/SEC --- ACC IN G,26,SY,90.,YMIN,DY)
      IF (YMIN) 105,110,110
  105 Y0=ABS(YMIN/DY)
      CALL PLOT(0.0,Y0,3)
      CALL PLOT(SX, Y0,2)
  110 DO 120 I=1,N
      IF (Y(I) .GT. YMAX) Y(I)=YMAX
      IF (Z(I) .GT. YMAX) Z(I)=YMAX
      IF (Y(I) .LT. YMIN) Y(I)=YMIN
```

```
      IF (Z(I) .LT. YMIN) Z(I)=YMIN
  120 CONTINUE
  130 CALL LINE(X,Y,N,1,10,1)
      CALL LINE(X,Z,N,1,10,3)
      H1=HEADL(JD)
      CALL SYMBOL(0.25,9.5,0.105,H1,0.0,9)
      CALL SYMBOL(0.25,9.3,0.105,6HREL TO,0.0,6)
      H1=HEADL(JR)
      CALL SYMBOL(0.25,9.1,0.105,H1,0.0,9)
      J=1
      CALL SYMBOL(0.5, 8.8,0.105,J,0.0,-1)
      CALL SYMBOL(0.65,8.75,0.105,3HVEL,0.0,3)
      J=3
      CALL SYMBOL(0.5, 8.55,0.105,J,0.0,-1)
      CALL SYMBOL(0.65,8.50,0.105,3HACC,0.0,3)
  140 CALL SYMBOL(0.25,9.8,0.105,4HTEST,0.0,4)
      CALL SYMBOL(0.75,9.8,0.105,TEST,0.0,5)
      CALL NUMBER(1.75,9.8,0.105,FLOAT(NP),0.0,-1)
      CALL SYMBOL(2.05,9.8,0.105,9HPOINT FIT,0.0,9)
      GO TO 999
C
C  PLOT THE COMPOSITE PLOT OF PARAMETERS VERSUS SLED.
C  NOTE: ORDINATE AND ABSCISSA SCALING IS FIXED.
C
  300 ZMIN=0.0
C     XMIN=-1.4-2.2*FLOAT(IRX)
      XMIN=-1.0
      DZ=0.4
      DX=0.4
      SX=10.0
      CALL AXIS(0.0,0.0,14HX DISP IN FEET,-14,SX,0.0,XMIN,DX)
      CALL AXIS(0.0,0.0,14HZ DISP IN FEET, 14,SY,90.0,ZMIN,DZ)
      CALL SYMBOL(0.25,9.5,0.105,16HDATA REL TO SLED,0.0,16)
```

```
      X(N1)=XMIN
      X(N2)=DX
      Z(N1)=ZMIN
      Z(N2)=DZ
      XMAX=SX*DX+XMIN
      ZMAX=SY*DZ+ZMIN
      Y0=10.0
      DO 310 J=1,6
      IF (ICAL(J+2)) 310,310,305
  305 H1=HEADL(J+2)
      Y0=Y0-0.25
      CALL SYMBOL(-1.75,Y0+0.05,0.105,J,0.0,-1)
      CALL SYMBOL(-1.60,Y0,0.105,H1,0.0,9)
  310 CONTINUE
      DO 325 J=1,6
      IF (ICAL(J+2)) 325,325,315
  315 II=0
      DO 320 I=I1,I2
      II=II+1
      X(II)=XX(I,J)
      Z(II)=ZZ(I,J)
      IF (X(II) .GT. XMAX) X(II)=XMAX
      IF (X(II) .LT. XMIN) X(II)=XMIN
      IF (Z(II) .GT. ZMAX) Z(II)=ZMAX
      IF (Z(II) .LT. ZMIN) Z(II)=ZMIN
  320 CONTINUE
      CALL LINE(X,Z,N,1,-1,J)
  325 CONTINUE
      GO TO 140
C
C  SETUP AND PLOT ANGULAR VEL AND ACCEL.
C
  400 CALL SCALE(Y,SY,N,1)
```

```
      CALL SCALE(Z,SY,N,1)
      YMIN=Y(N1)
      ZMIN=Z(N1)
      DY=  Y(N2)
      DZ=  Z(N2)
      WRITE(6,2000) YMIN,DY,ZMIN,DZ
      CALL AXIS(0.0,0.0,22HANGULAR VEL -- RAD/SEC,    22,SY,90.,YMIN,DY)
      CALL AXIS(SX,0.0,26HANGULAR ACC -- RAD/SEC/SEC,-26,SY,90.,ZMIN,DZ)
      GO TO 130
  999 CALL PLOT(SX+3.0,0.0,-3)
      RETURN
 2000 FORMAT(//4X,*THE ABOVE VEL AND ACCEL DATA ARE PLOTTED;  YMIN=*,
     1F10.2,*   DY=*,F8.2 ,5X,* ZMIN=*,F10.2,*   DZ=*,F8.2)
      END
      SUBROUTINE SM(X,Y,YC,N,NP)
C  NP MUST BE AN ODD INTEGER .GE. 3.
C  COMPUTE THE COEFFICIENTS FOR A QUADRATIC LEAST SQUARES FIT OF 'NP'
C  POINTS AND COMPUTE THE FIT OF THE DATA (NO DERIVATIVES) 'YC(I)'.
      DIMENSION C(3),X(1),Y(1),YC(1)
      M=(NP-1)/2
      NN=N-M
      N1=NN+1
      DO 10 I=1,M
   10 YC(I)=0.0
      DO 20 I=N1,N
   20 YC(I)=0.0
      MM=M+1
      DO 100 I=MM,NN
      N1=I-M
      N2=I+M
      CALL QLSQ(X,Y,N1,N2,C)
      YC(I)=C(1)*X(I)*X(I)+C(2)*X(I)+C(3)
C     YP(I)=2.0*C(1)*X(I)+C(2)
```

```
C     YPP(I)=2.0*C(1)
  100 CONTINUE
      RETURN
      END
      SUBROUTINE DERIV1(X,Y,YP,N,NP,ID)
C  NP MUST BE AN ODD INTEGER .GE. 3.
C  ID=1 FOR FIRST DERIVATIVE.
C  ID=2 FOR SECOND DERIVATIVE.
C  COMPUTE THE COEFFICIENTS FOR A QUADRATIC LEAST SQUARES FIT OF 'NP'
C  POINTS AND COMPUTE THE FIRST DERIVATIVE 'YP(I)'.
      DIMENSION C(3),X(1),Y(1),YP(1)
      M=(NP-1)/2
      K=M+M*ID
      NN=N-K
      N1=NN+1
      DO 10 I=1,K
   10 YP(I)=0.0
      DO 20 I=N1,N
   20 YP(I)=0.0
      MM=K+1
      DO 100 I=MM,NN
      N1=I-M
      N2=I+M
      CALL QLSQ(X,Y,N1,N2,C)
      YP(I)=2.0*C(1)*X(I)+C(2)
C     YC(I)=C(1)*X(I)*X(I)+C(2)*X(I)+C(3)
C     YPP(I)=2.0*C(1)
  100 CONTINUE
      RETURN
      END
      SUBROUTINE QLSQ(X,Y,N1,N2,C)
      DIMENSION X(1),Y(1),C(1)
C
```

```
C  THIS SUBROUTINE COMPUTES THE QUADRATIC LEAST SQUARE COEFFICIENTS
C  'C(3)' FOR NP DATA POINTS (NP MUST BE AN ODD INTEGER  .GE. 3).
C  THE DATA NEED NOT BE EQUALLY SPACED.
C     C(1)*(X**2)+C(2)*X+C(3)=Y
C     C(1)*X+C(2)=Y
C  SUBSTITUTE XP=X-FF,  WHERE FF IS X((N1+N2)/2)
C  THEN C(3)=C(3)+C(1)*FF*FF-C(2)*FF
C       C(2)=C(2)-2.0*C(1)*FF
C       C(1)=C(1)
C
      F(A1,A2,A3,B1,B2,B3,C1,C2,C3)=A1*(B2*C3-B3*C2)+A2*(B3*C1-B1*C3)+A3
     1*(B1*C2-B2*C1)
      FN=FLOAT(N2-N1+1)
      NN=(N1+N2)/2
      FF=X(NN)
      Z1=0
      Z2=0
      Z3=0
      Z4=0
      Z5=0
      Z6=0
      Z7=0
   10 DO 20 I=N1,N2
      X2=X(I)-FF
      X1=X2*X2
      Z1=Z1+X2
      Z2=Z2+X1
      Z3=Z3+X1*X2
      Z4=Z4+X1*X1
      Z5=Z5+Y(I)
      Z6=Z6+X2*Y(I)
      Z7=Z7+X1*Y(I)
   20 CONTINUE
```

```
DEN=F(Z4,Z3,Z2,Z3,Z2,Z1,Z2,Z1,FN)
C(1)=F(Z7,Z6,Z5,Z3,Z2,Z1,Z2,Z1,FN)/DEN
C(2)=F(Z4,Z3,Z2,Z7,Z6,Z5,Z2,Z1,FN)/DEN
C(3)=F(Z4,Z3,Z2,Z3,Z2,Z1,Z7,Z6,Z5)/DEN
C(3)=C(3)+C(1)*FF*FF-C(2)*FF
C(2)=C(2)-2.0*C(1)*FF
RETURN
END
```

APPENDIX D

TYPICAL LISTINGS AND PLOTS GENERATED BY HIFPD

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT G 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

TEST	N	DT	IRX	ITYPE	IRP	IPL	IPA	IPC	M	SETS:	1	2	3	4	5	6
1039	151	490.243	1	0	0	0	0	0	6		32	42	52	62	72	82

	SLED	HIP	KNEE	SHOULDER	ELBOW	HEAD PT. 1	HEAD PT. 2
CALIB DATA IN COUNTS PER FOOT:	1651.745	1637.978	1614.497	1681.373	1715.118	1519.793	1464.613

AVERAGE TIME INCREMENT BETWEEN POINTS: .00204

NUMBER OF FRAMES READ: 151 FRAMES

REVERSE POLARITY OF X-AXIS DATA (MULT. BY -1.0): YES

PRINT LISTING OF INPUT DATA IN COUNTS: YES

LINEAR VELOCITY AND ACCELERATION DATA: PRINT? YES PLOT? YES

ANGULAR VELOCITY AND ACCELERATION DATA: PRINT? YES PLOT? YES

PARAMETERS RELATIVE TO SLED DISPLACEMENTS: PRINT? YES PLOT? YES

LINEAR DISPLACEMENT, VELOCITY AND ACCELERATION DATA WILL BE COMPUTED FOR THE FOLLOWING:

1) HIP MOTION RELATIVE TO THE SLED
2) KNEE MOTION RELATIVE TO THE SLED
3) SHOULDER MOTION RELATIVE TO THE SLED
4) ELBOW MOTION RELATIVE TO THE SLED
5) HEAD PT. 1 MOTION RELATIVE TO THE SLED
6) HEAD PT. 2 MOTION RELATIVE TO THE SLED

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1039, 751117, NYLON 11 POINT QUADRATIC FIT

THE FOLLOWING IS A LISTING OF THE INPUT DATA IN COUNTS:

FRAME	RANGE		SLED		HIP		KNEE		SHOULDER		ELBOW		HEAD PT. 1		HEAD PT.2	
NO.	X	Z	X	Z	X	Z	X	Z	X	Z	X	Z	X	Z	X	Z
0	-154.	-2194.	-1817.	-2367.	-1893.	-1849.	650.	-1716.	-2689.	967.	-2519.	-919.	-2483.	1739.	-1976.	2404.
1	-165.	-2193.	-1819.	-2365.	-1899.	-1849.	652.	-1712.	-2694.	963.	-2520.	-914.	-2494.	1742.	-1964.	2389.
2	-165.	-2192.	-1821.	-2363.	-1897.	-1845.	648.	-1712.	-2693.	966.	-2521.	-914.	-2497.	1732.	-1976.	2396.
3	-162.	-2199.	-1820.	-2374.	-1899.	-1855.	649.	-1716.	-2694.	956.	-2518.	-923.	-2492.	1727.	-1979.	2395.
4	-165.	-2202.	-1818.	-2372.	-1898.	-1853.	652.	-1716.	-2696.	956.	-2522.	-929.	-2497.	1725.	-1978.	2394.
5	-161.	-2203.	-1820.	-2372.	-1900.	-1858.	657.	-1718.	-2694.	955.	-2520.	-922.	-2495.	1723.	-1974.	2400.
6	-155.	-2200.	-1818.	-2371.	-1892.	-1852.	658.	-1708.	-2691.	950.	-2511.	-922.	-2486.	1731.	-1973.	2406.
7	-162.	-2198.	-1820.	-2371.	-1893.	-1850.	662.	-1715.	-2695.	960.	-2518.	-919.	-2498.	1733.	-1980.	2413.
8	-163.	-2193.	-1823.	-2365.	-1896.	-1847.	663.	-1706.	-2693.	971.	-2519.	-908.	-2504.	1737.	-1984.	2420.
9	-156.	-2193.	-1817.	-2367.	-1893.	-1852.	666.	-1710.	-2688.	967.	-2513.	-913.	-2487.	1750.	-2022.	2418.
10	-162.	-2188.	-1823.	-2362.	-1904.	-1845.	657.	-1707.	-2698.	974.	-2522.	-900.	-2510.	1738.	-2006.	2430.
11	-162.	-2196.	-1825.	-2371.	-1898.	-1852.	659.	-1713.	-2691.	972.	-2521.	-914.	-2485.	1742.	-2024.	2429.
12	-159.	-2193.	-1819.	-2365.	-1901.	-1850.	659.	-1708.	-2697.	970.	-2521.	-910.	-2489.	1747.	-2024.	2423.
13	-160.	-2195.	-1820.	-2369.	-1896.	-1854.	660.	-1713.	-2697.	963.	-2520.	-911.	-2497.	1740.	-2027.	2432.
14	-152.	-2196.	-1814.	-2371.	-1891.	-1854.	662.	-1711.	-2690.	958.	-2514.	-915.	-2485.	1736.	-2018.	2426.
15	-158.	-2200.	-1820.	-2372.	-1896.	-1856.	655.	-1709.	-2689.	962.	-2515.	-917.	-2500.	1733.	-2025.	2419.
16	-159.	-2196.	-1818.	-2366.	-1897.	-1850.	656.	-1706.	-2695.	965.	-2515.	-914.	-2493.	1739.	-2020.	2426.
17	-158.	-2194.	-1819.	-2366.	-1898.	-1847.	655.	-1712.	-2693.	969.	-2515.	-911.	-2500.	1741.	-2021.	2428.
18	-159.	-2193.	-1822.	-2360.	-1900.	-1848.	660.	-1710.	-2694.	964.	-2519.	-907.	-2494.	1736.	-2020.	2422.
19	-161.	-2192.	-1818.	-2362.	-1896.	-1848.	660.	-1708.	-2693.	966.	-2516.	-908.	-2496.	1741.	-2022.	2427.
20	-161.	-2193.	-1819.	-2364.	-1892.	-1847.	660.	-1715.	-2689.	967.	-2518.	-912.	-2496.	1739.	-2019.	2427.
21	-157.	-2194.	-1813.	-2367.	-1892.	-1847.	670.	-1715.	-2683.	968.	-2510.	-908.	-2476.	1736.	-2019.	2426.
22	-163.	-2198.	-1823.	-2368.	-1899.	-1853.	660.	-1711.	-2697.	963.	-2519.	-915.	-2481.	1729.	-2027.	2423.
23	-164.	-2202.	-1827.	-2374.	-1897.	-1851.	660.	-1713.	-2694.	958.	-2523.	-911.	-2491.	1732.	-2029.	2417.
24	-163.	-2200.	-1823.	-2373.	-1898.	-1855.	659.	-1722.	-2697.	958.	-2523.	-914.	-2498.	1727.	-2031.	2417.
25	-171.	-2199.	-1831.	-2374.	-1902.	-1854.	650.	-1712.	-2704.	962.	-2526.	-917.	-2504.	1733.	-2042.	2425.
26	-164.	-2204.	-1825.	-2380.	-1899.	-1861.	662.	-1721.	-2696.	957.	-2516.	-921.	-2505.	1724.	-2035.	2413.
27	-156.	-2198.	-1814.	-2377.	-1891.	-1854.	666.	-1718.	-2692.	953.	-2513.	-922.	-2479.	1719.	-2027.	2414.
28	-155.	-2198.	-1816.	-2374.	-1883.	-1851.	674.	-1718.	-2689.	951.	-2507.	-921.	-2500.	1738.	-2021.	2418.
29	-157.	-2204.	-1818.	-2381.	-1887.	-1858.	670.	-1719.	-2692.	953.	-2512.	-921.	-2496.	1724.	-2024.	2413.
30	-150.	-2197.	-1811.	-2376.	-1876.	-1855.	674.	-1712.	-2682.	953.	-2500.	-914.	-2489.	1731.	-2021.	2420.
31	-152.	-2201.	-1813.	-2380.	-1882.	-1861.	679.	-1711.	-2681.	948.	-2499.	-928.	-2480.	1721.	-2023.	2413.
32	-150.	-2207.	-1812.	-2386.	-1871.	-1861.	687.	-1719.	-2678.	942.	-2493.	-931.	-2492.	1715.	-2013.	2403.
33	-147.	-2210.	-1806.	-2389.	-1856.	-1862.	696.	-1723.	-2668.	942.	-2482.	-934.	-2475.	1718.	-2016.	2406.
34	-143.	-2208.	-1805.	-2392.	-1853.	-1865.	701.	-1724.	-2661.	938.	-2472.	-939.	-2473.	1714.	-2007.	2399.
35	-138.	-2212.	-1797.	-2398.	-1840.	-1875.	720.	-1723.	-2645.	934.	-2457.	-944.	-2469.	1705.	-1997.	2388.
36	-140.	-2217.	-1802.	-2401.	-1838.	-1881.	718.	-1735.	-2640.	922.	-2449.	-954.	-2444.	1638.	-1995.	2382.
37	-141.	-2221.	-1800.	-2407.	-1830.	-1889.	740.	-1730.	-2629.	919.	-2436.	-953.	-2446.	1703.	-1982.	2381.
38	-142.	-2221.	-1801.	-2405.	-1822.	-1898.	743.	-1735.	-2620.	926.	-2427.	-960.	-2432.	1696.	-1977.	2382.
39	-146.	-2224.	-1808.	-2401.	-1820.	-1899.	756.	-1737.	-2603.	925.	-2412.	-951.	-2422.	1690.	-1967.	2378.
40	-134.	-2217.	-1794.	-2399.	-1800.	-1878.	773.	-1736.	-2578.	935.	-2381.	-948.	-2390.	1711.	-1942.	2386.
41	-139.	-2217.	-1798.	-2397.	-1791.	-1883.	776.	-1728.	-2561.	927.	-2364.	-947.	-2374.	1731.	-1931.	2380.
42	-126.	-2211.	-1785.	-2391.	-1770.	-1868.	800.	-1720.	-2531.	941.	-2332.	-945.	-2353.	1706.	-1910.	2385.
43	-122.	-2209.	-1785.	-2392.	-1749.	-1873.	821.	-1711.	-2507.	941.	-2307.	-944.	-2324.	1707.	-1865.	2394.
44	-128.	-2216.	-1787.	-2398.	-1744.	-1875.	832.	-1721.	-2489.	937.	-2286.	-951.	-2315.	1693.	-1850.	2390.
45	-128.	-2215.	-1789.	-2399.	-1733.	-1882.	855.	-1729.	-2466.	930.	-2261.	-952.	-2278.	1704.	-1827.	2375.
46	-136.	-2214.	-1795.	-2398.	-1714.	-1874.	858.	-1726.	-2446.	932.	-2239.	-951.	-2272.	1685.	-1804.	2378.
47	-139.	-2212.	-1798.	-2392.	-1708.	-1876.	881.	-1721.	-2423.	930.	-2213.	-948.	-2252.	1696.	-1794.	2380.
48	-140.	-2210.	-1802.	-2390.	-1693.	-1871.	895.	-1726.	-2399.	934.	-2187.	-946.	-2227.	1695.	-1766.	2379.
49	-142.	-2205.	-1801.	-2389.	-1680.	-1875.	909.	-1718.	-2376.	934.	-2158.	-945.	-2191.	1708.	-1739.	2376.
50	-142.	-2202.	-1801.	-2383.	-1664.	-1861.	932.	-1710.	-2346.	940.	-2119.	-933.	-2173.	1690.	-1705.	2368.
51	-141.	-2207.	-1797.	-2385.	-1648.	-1857.	958.	-1721.	-2316.	938.	-2082.	-942.	-2149.	1692.	-1666.	2365.
52	-146.	-2206.	-1807.	-2383.	-1636.	-1859.	971.	-1723.	-2295.	943.	-2046.	-936.	-2113.	1638.	-1630.	2370.

53	-150.	-2201.	-1810.	-2383.	-1633.	-1858.	978.	-1720.	-2275.	950.	-2014.	-930.	-2093.	1699.	-1613.	2360.
54	-153.	-2200.	-1812.	-2378.	-1619.	-1856.	987.	-1720.	-2245.	947.	-1978.	-923.	-2057.	1731.	-1572.	2362.
55	-162.	-2206.	-1820.	-2379.	-1613.	-1864.	999.	-1727.	-2235.	941.	-1940.	-926.	-2040.	1679.	-1530.	2362.
56	-167.	-2199.	-1828.	-2374.	-1604.	-1852.	1008.	-1719.	-2223.	954.	-1899.	-911.	-2008.	1696.	-1492.	2361.
57	-172.	-2197.	-1830.	-2368.	-1598.	-1850.	1003.	-1723.	-2214.	961.	-1866.	-901.	-1988.	1694.	-1473.	2359.
58	-169.	-2198.	-1830.	-2368.	-1588.	-1844.	1015.	-1727.	-2178.	959.	-1826.	-894.	-1963.	1700.	-1419.	2369.
59	-178.	-2209.	-1837.	-2378.	-1590.	-1855.	1020.	-1738.	-2171.	951.	-1787.	-900.	-1942.	1688.	-1396.	2337.
60	-174.	-2214.	-1835.	-2378.	-1576.	-1857.	1022.	-1742.	-2158.	949.	-1740.	-893.	-1915.	1661.	-1360.	2315.
61	-169.	-2203.	-1830.	-2374.	-1564.	-1842.	1030.	-1737.	-2155.	960.	-1690.	-881.	-1905.	1670.	-1320.	2317.
62	-164.	-2191.	-1825.	-2360.	-1561.	-1831.	1033.	-1724.	-2153.	967.	-1649.	-859.	-1891.	1680.	-1297.	2308.
63	-165.	-2187.	-1830.	-2362.	-1559.	-1831.	1029.	-1723.	-2153.	973.	-1615.	-846.	-1885.	1675.	-1277.	2294.
64	-158.	-2201.	-1819.	-2374.	-1563.	-1853.	1030.	-1727.	-2147.	966.	-1564.	-845.	-1867.	1645.	-1272.	2260.
65	-155.	-2205.	-1817.	-2380.	-1552.	-1860.	1027.	-1735.	-2146.	948.	-1516.	-833.	-1854.	1625.	-1230.	2224.
66	-155.	-2204.	-1816.	-2376.	-1557.	-1854.	1024.	-1730.	-2154.	948.	-1473.	-821.	-1852.	1630.	-1212.	2200.
67	-163.	-2199.	-1827.	-2373.	-1569.	-1854.	1007.	-1731.	-2162.	945.	-1439.	-793.	-1852.	1611.	-1186.	2163.
68	-167.	-2189.	-1829.	-2362.	-1580.	-1844.	994.	-1723.	-2163.	963.	-1398.	-759.	-1839.	1624.	-1159.	2152.
69	-176.	-2197.	-1838.	-2365.	-1594.	-1849.	970.	-1729.	-2171.	955.	-1361.	-743.	-1838.	1600.	-1135.	2116.
70	-183.	-2199.	-1848.	-2369.	-1609.	-1846.	951.	-1728.	-2178.	950.	-1330.	-725.	-1842.	1574.	-1112.	2071.
71	-184.	-2200.	-1847.	-2370.	-1618.	-1849.	942.	-1724.	-2193.	946.	-1297.	-699.	-1837.	1576.	-1096.	2035.
72	-183.	-2197.	-1847.	-2367.	-1624.	-1848.	933.	-1726.	-2197.	939.	-1260.	-666.	-1840.	1561.	-1073.	1998.
73	-182.	-2188.	-1848.	-2362.	-1637.	-1849.	916.	-1714.	-2203.	932.	-1227.	-630.	-1833.	1560.	-1086.	1852.
74	-178.	-2189.	-1837.	-2364.	-1635.	-1850.	914.	-1707.	-2208.	930.	-1192.	-605.	-1830.	1537.	-1026.	1908.
75	-178.	-2192.	-1837.	-2367.	-1642.	-1850.	892.	-1709.	-2220.	920.	-1162.	-575.	-1830.	1521.	-1009.	1863.
76	-176.	-2200.	-1837.	-2377.	-1666.	-1864.	889.	-1714.	-2220.	904.	-1128.	-556.	-1823.	1513.	-984.	1809.
77	-177.	-2189.	-1836.	-2358.	-1661.	-1852.	867.	-1698.	-2232.	902.	-1110.	-512.	-1831.	1506.	-1005.	1785.
78	-180.	-2190.	-1840.	-2360.	-1677.	-1849.	852.	-1692.	-2241.	901.	-1095.	-479.	-1819.	1514.	-988.	1748.
79	-175.	-2188.	-1839.	-2359.	-1672.	-1851.	843.	-1693.	-2246.	900.	-1071.	-446.	-1812.	1499.	-964.	1712.
80	-181.	-2190.	-1841.	-2360.	-1686.	-1854.	819.	-1689.	-2259.	891.	-1064.	-431.	-1802.	1477.	-956.	1674.
81	-173.	-2194.	-1837.	-2371.	-1693.	-1856.	815.	-1695.	-2264.	875.	-1042.	-410.	-1802.	1465.	-947.	1622.
82	-166.	-2201.	-1828.	-2377.	-1692.	-1868.	809.	-1695.	-2265.	864.	-1030.	-392.	-1791.	1446.	-926.	1570.
83	-161.	-2198.	-1824.	-2372.	-1695.	-1863.	803.	-1690.	-2273.	869.	-1022.	-375.	-1779.	1456.	-911.	1541.
84	-155.	-2195.	-1817.	-2368.	-1702.	-1863.	797.	-1677.	-2277.	868.	-1010.	-349.	-1779.	1447.	-909.	1530.
85	-157.	-2202.	-1819.	-2376.	-1714.	-1872.	779.	-1675.	-2290.	865.	-1021.	-346.	-1772.	1453.	-908.	1505.
86	-152.	-2196.	-1814.	-2369.	-1722.	-1869.	767.	-1656.	-2299.	870.	-1022.	-331.	-1761.	1446.	-916.	1499.
87	-149.	-2195.	-1813.	-2374.	-1725.	-1872.	766.	-1652.	-2305.	870.	-1026.	-326.	-1759.	1446.	-918.	1482.
88	-156.	-2196.	-1818.	-2376.	-1735.	-1872.	750.	-1645.	-2314.	878.	-1038.	-303.	-1749.	1454.	-917.	1472.
89	-156.	-2199.	-1821.	-2379.	-1742.	-1873.	735.	-1632.	-2314.	887.	-1047.	-296.	-1748.	1452.	-905.	1464.
90	-159.	-2206.	-1823.	-2384.	-1749.	-1870.	729.	-1620.	-2317.	897.	-1050.	-301.	-1740.	1456.	-898.	1467.
91	-166.	-2200.	-1829.	-2373.	-1760.	-1871.	708.	-1609.	-2320.	913.	-1067.	-286.	-1733.	1458.	-897.	1467.
92	-167.	-2205.	-1826.	-2379.	-1762.	-1870.	703.	-1596.	-2320.	915.	-1077.	-289.	-1719.	1454.	-888.	1475.
93	-164.	-2200.	-1823.	-2371.	-1764.	-1871.	691.	-1574.	-2319.	943.	-1097.	-282.	-1710.	1464.	-877.	1491.
94	-161.	-2197.	-1820.	-2370.	-1763.	-1860.	681.	-1561.	-2319.	962.	-1105.	-284.	-1702.	1479.	-870.	1496.
95	-167.	-2199.	-1825.	-2372.	-1768.	-1863.	674.	-1551.	-2323.	966.	-1123.	-273.	-1696.	1492.	-858.	1493.
96	-159.	-2201.	-1821.	-2374.	-1766.	-1864.	669.	-1542.	-2318.	983.	-1132.	-286.	-1686.	1488.	-852.	1497.
97	-162.	-2199.	-1826.	-2373.	-1769.	-1856.	667.	-1535.	-2316.	1006.	-1153.	-282.	-1683.	1509.	-840.	1521.
98	-160.	-2190.	-1821.	-2366.	-1765.	-1843.	659.	-1518.	-2315.	1026.	-1163.	-271.	-1673.	1516.	-831.	1542.
99	-158.	-2191.	-1819.	-2365.	-1764.	-1840.	662.	-1506.	-2309.	1045.	-1180.	-275.	-1672.	1521.	-824.	1549.
100	-156.	-2195.	-1819.	-2366.	-1765.	-1836.	657.	-1501.	-2305.	1059.	-1196.	-277.	-1650.	1518.	-812.	1562.
101	-160.	-2195.	-1827.	-2367.	-1771.	-1834.	646.	-1491.	-2305.	1075.	-1226.	-278.	-1651.	1525.	-799.	1575.
102	-158.	-2192.	-1822.	-2364.	-1765.	-1830.	652.	-1481.	-2287.	1094.	-1225.	-281.	-1648.	1541.	-789.	1569.
103	-162.	-2197.	-1826.	-2371.	-1770.	-1828.	641.	-1477.	-2303.	1097.	-1245.	-289.	-1637.	1547.	-792.	1599.
104	-164.	-2192.	-1833.	-2365.	-1778.	-1822.	645.	-1465.	-2310.	1121.	-1260.	-287.	-1638.	1559.	-790.	1633.
105	-170.	-2187.	-1836.	-2360.	-1784.	-1813.	631.	-1456.	-2312.	1144.	-1291.	-288.	-1642.	1565.	-794.	1638.
106	-170.	-2192.	-1835.	-2364.	-1788.	-1814.	625.	-1457.	-2308.	1137.	-1304.	-290.	-1635.	1557.	-793.	1639.
107	-173.	-2192.	-1837.	-2364.	-1789.	-1806.	628.	-1446.	-2315.	1150.	-1329.	-293.	-1642.	1585.	-792.	1663.
108	-177.	-2193.	-1843.	-2367.	-1796.	-1806.	611.	-1443.	-2314.	1152.	-1349.	-298.	-1649.	1584.	-798.	1695.
109	-175.	-2192.	-1841.	-2367.	-1794.	-1806.	614.	-1432.	-2312.	1163.	-1359.	-301.	-1644.	1591.	-792.	1703.
110	-177.	-2198.	-1842.	-2371.	-1805.	-1806.	612.	-1433.	-2319.	1161.	-1372.	-304.	-1644.	1590.	-799.	1715.
111	-180.	-2200.	-1845.	-2373.	-1802.	-1796.	600.	-1421.	-2319.	1157.	-1391.	-303.	-1645.	1585.	-805.	1728.
112	-180.	-2199.	-1845.	-2372.	-1812.	-1797.	598.	-1416.	-2318.	1170.	-1406.	-303.	-1652.	1598.	-805.	1747.
113	-181.	-2195.	-1845.	-2369.	-1814.	-1796.	594.	-1410.	-2325.	1178.	-1420.	-304.	-1653.	1598.	-807.	1775.
114	-180.	-2195.	-1845.	-2370.	-1817.	-1793.	589.	-1401.	-2338.	1188.	-1431.	-296.	-1647.	1606.	-818.	1789.
115	-181.	-2189.	-1844.	-2363.	-1826.	-1784.	583.	-1394.	-2346.	1192.	-1445.	-287.	-1656.	1625.	-821.	1806.
116	-181.	-2193.	-1846.	-2367.	-1829.	-1784.	585.	-1385.	-2343.	1196.	-1451.	-283.	-1653.	1621.	-820.	1826.
117	-181.	-2199.	-1847.	-2372.	-1835.	-1783.	582.	-1386.	-2353.	1195.	-1461.	-285.	-1673.	1620.	-829.	1834.
118	-181.	-2198.	-1844.	-2370.	-1839.	-1783.	579.	-1377.	-2362.	1191.	-1468.	-285.	-1675.	1625.	-843.	1853.

119	-180.	-2198.	-1846.	-2370.	-1842.	-1788.	567.	-1374.	-2367.	1189.	-1471.	-285.	-1680.	1621.	-848.	1858.
120	-175.	-2198.	-1840.	-2368.	-1842.	-1784.	573.	-1364.	-2370.	1183.	-1476.	-281.	-1670.	1615.	-850.	1861.
121	-173.	-2204.	-1839.	-2375.	-1846.	-1786.	577.	-1359.	-2370.	1182.	-1479.	-282.	-1679.	1637.	-870.	1869.
122	-169.	-2205.	-1834.	-2378.	-1843.	-1783.	572.	-1358.	-2368.	1189.	-1473.	-278.	-1686.	1618.	-880.	1884.
123	-163.	-2205.	-1829.	-2375.	-1841.	-1779.	572.	-1351.	-2370.	1193.	-1472.	-272.	-1686.	1641.	-880.	1897.
124	-170.	-2202.	-1835.	-2373.	-1857.	-1786.	560.	-1347.	-2380.	1179.	-1486.	-267.	-1692.	1632.	-890.	1892.
125	-165.	-2201.	-1827.	-2374.	-1855.	-1783.	565.	-1339.	-2398.	1184.	-1488.	-268.	-1703.	1631.	-916.	1910.
126	-158.	-2198.	-1820.	-2371.	-1851.	-1781.	579.	-1325.	-2374.	1189.	-1478.	-253.	-1705.	1650.	-907.	1913.
127	-166.	-2199.	-1821.	-2367.	-1860.	-1774.	568.	-1319.	-2382.	1181.	-1480.	-251.	-1714.	1653.	-918.	1920.
128	-165.	-2201.	-1823.	-2369.	-1867.	-1787.	563.	-1320.	-2390.	1176.	-1487.	-250.	-1718.	1643.	-927.	1933.
129	-169.	-2201.	-1825.	-2370.	-1871.	-1778.	558.	-1311.	-2399.	1176.	-1491.	-235.	-1734.	1666.	-946.	1933.
130	-167.	-2197.	-1831.	-2368.	-1869.	-1776.	554.	-1307.	-2406.	1166.	-1490.	-233.	-1743.	1654.	-958.	1936.
131	-158.	-2201.	-1821.	-2371.	-1866.	-1783.	558.	-1299.	-2402.	1164.	-1490.	-236.	-1739.	1657.	-957.	1943.
132	-162.	-2202.	-1826.	-2371.	-1867.	-1781.	561.	-1296.	-2412.	1161.	-1493.	-240.	-1758.	1656.	-943.	1948.
133	-166.	-2203.	-1829.	-2372.	-1872.	-1786.	554.	-1300.	-2421.	1161.	-1500.	-237.	-1766.	1663.	-982.	1947.
134	-166.	-2201.	-1827.	-2376.	-1875.	-1789.	560.	-1289.	-2428.	1149.	-1497.	-241.	-1778.	1655.	-998.	1957.
135	-166.	-2196.	-1827.	-2370.	-1872.	-1787.	554.	-1289.	-2440.	1143.	-1499.	-233.	-1801.	1664.	-1014.	1956.
136	-165.	-2201.	-1823.	-2378.	-1866.	-1789.	559.	-1289.	-2440.	1139.	-1501.	-237.	-1801.	1666.	-1018.	1961.
137	-167.	-2203.	-1830.	-2377.	-1872.	-1794.	562.	-1285.	-2453.	1146.	-1505.	-231.	-1816.	1657.	-1039.	1974.
138	-168.	-2202.	-1830.	-2381.	-1868.	-1792.	564.	-1284.	-2460.	1137.	-1509.	-227.	-1824.	1677.	-1039.	1976.
139	-168.	-2201.	-1828.	-2373.	-1869.	-1791.	566.	-1283.	-2468.	1136.	-1506.	-221.	-1827.	1676.	-1045.	1977.
140	-171.	-2203.	-1834.	-2375.	-1870.	-1794.	558.	-1275.	-2479.	1139.	-1513.	-219.	-1835.	1674.	-1053.	1983.
141	-170.	-2202.	-1835.	-2381.	-1866.	-1798.	555.	-1292.	-2485.	1131.	-1516.	-229.	-1850.	1677.	-1080.	1993.
142	-171.	-2198.	-1835.	-2375.	-1859.	-1796.	559.	-1284.	-2494.	1131.	-1519.	-219.	-1862.	1686.	-1093.	2003.
143	-183.	-2198.	-1841.	-2372.	-1866.	-1800.	548.	-1291.	-2505.	1126.	-1534.	-228.	-1878.	1678.	-1104.	2008.
144	-179.	-2203.	-1837.	-2377.	-1857.	-1806.	561.	-1294.	-2510.	1120.	-1533.	-229.	-1886.	1676.	-1126.	2014.
145	-185.	-2198.	-1848.	-2375.	-1865.	-1801.	554.	-1286.	-2526.	1130.	-1545.	-225.	-1898.	1695.	-1138.	2030.
146	-179.	-2201.	-1840.	-2373.	-1856.	-1802.	547.	-1298.	-2530.	1126.	-1535.	-224.	-1909.	1700.	-1156.	2028.
147	-181.	-2205.	-1844.	-2377.	-1851.	-1809.	558.	-1306.	-2542.	1107.	-1545.	-245.	-1930.	1674.	-1175.	2021.
148	-183.	-2205.	-1846.	-2379.	-1853.	-1813.	551.	-1309.	-2552.	1119.	-1554.	-252.	-1927.	1687.	-1178.	2041.
149	-185.	-2201.	-1850.	-2373.	-1847.	-1810.	542.	-1310.	-2550.	1118.	-1557.	-245.	-1942.	1695.	-1195.	2048.
150	-188.	-2204.	-1848.	-2383.	-1850.	-1816.	550.	-1328.	-2557.	1110.	-1555.	-252.	-1937.	1697.	-1204.	2046.

DATE: 9 JUN 77 TEST NUMBER: 1639

RSD STUDY, SUBJECT G-2, RUN1639, 761117, NYLON 11 POINT QUADRATIC FIT

THE FOLLOWING IS A LISTING OF D(I)-DR(I)-D(I-1)+DR(I-1) IN COUNTS:

FRAME	RANGE		SLED		HIP		KNEE		SHOULDER		ELBOW		HEAD PT. 1		HEAD PT. 2	
NO.	X	Z	X	Z	X	Z	X	Z	X	Z	X	Z	X	Z	X	Z
1	-11.	1.	3.	1.	5.	-1.	13.	3.	6.	-5.	10.	4.	0.	2.	23.	-16.
2	0.	1.	-2.	1.	2.	3.	-4.	-1.	1.	2.	-1.	-1.	-3.	-11.	-12.	6.
3	3.	-7.	-2.	-4.	-5.	-3.	-2.	3.	-4.	-3.	0.	-2.	2.	2.	-6.	6.
4	-3.	-3.	5.	5.	4.	5.	6.	3.	1.	3.	-1.	-3.	-2.	1.	4.	2.
5	4.	-1.	-6.	1.	-6.	-4.	1.	-1.	-2.	0.	-2.	8.	-2.	-1.	0.	7.
6	6.	3.	-4.	-2.	2.	3.	-5.	7.	-3.	-8.	3.	-3.	3.	5.	-5.	3.
7	-7.	2.	5.	-2.	6.	0.	11.	-9.	3.	8.	0.	1.	-5.	0.	0.	5.
8	-1.	5.	-2.	1.	-2.	-2.	2.	4.	3.	6.	0.	6.	-5.	-1.	-3.	2.
9	7.	0.	-1.	-2.	-4.	-5.	-4.	-4.	-2.	-4.	-1.	-5.	10.	13.	-45.	-2.
10	-6.	5.	0.	0.	-5.	2.	-3.	-2.	-4.	2.	-3.	8.	-17.	-17.	22.	7.
11	3.	-8.	-2.	-1.	6.	1.	2.	2.	7.	6.	1.	-6.	25.	12.	-18.	7.
12	3.	3.	3.	3.	-6.	-1.	-3.	2.	-9.	-5.	-3.	1.	-7.	2.	-3.	-9.
13	-1.	-2.	0.	-2.	6.	-2.	2.	-3.	1.	-5.	2.	1.	-7.	-5.	-2.	11.
14	8.	-1.	-2.	-1.	-3.	1.	-6.	3.	-1.	-4.	-2.	-3.	4.	-3.	1.	-5.
15	-6.	-4.	3.	3.	1.	2.	-1.	6.	7.	8.	5.	2.	-9.	1.	-1.	-3.
16	-1.	4.	3.	2.	0.	2.	2.	-1.	-5.	-1.	1.	-1.	8.	2.	6.	3.
17	1.	2.	-2.	-2.	-2.	1.	-2.	-8.	1.	2.	-1.	1.	-8.	0.	-2.	0.
18	-1.	1.	-2.	5.	-1.	-2.	6.	1.	0.	-6.	-3.	3.	7.	-6.	2.	-7.
19	-2.	1.	6.	-3.	6.	-1.	2.	1.	3.	1.	5.	-2.	0.	4.	0.	4.
20	0.	-1.	-1.	-1.	4.	2.	0.	-6.	4.	2.	-2.	-3.	0.	-1.	3.	1.
21	4.	-1.	2.	-2.	-4.	1.	6.	1.	2.	2.	4.	5.	16.	-2.	-4.	0.
22	-6.	-4.	-4.	3.	-1.	-2.	-4.	8.	-8.	-1.	-3.	-3.	1.	-3.	-2.	1.
23	-1.	-4.	-3.	-2.	3.	6.	1.	2.	4.	-1.	-3.	8.	-9.	7.	-1.	-2.
24	1.	2.	3.	-1.	2.	-6.	-2.	-11.	-4.	-2.	-1.	-5.	-8.	-7.	-3.	-2.
25	-8.	1.	0.	-2.	4.	0.	-1.	9.	1.	3.	5.	-4.	2.	5.	-3.	7.
26	7.	-5.	-1.	-1.	-4.	-2.	5.	-4.	1.	0.	3.	1.	-8.	-4.	0.	-7.
27	8.	6.	3.	-3.	0.	1.	-4.	-3.	-4.	-10.	-5.	-7.	18.	-11.	0.	-5.
28	1.	0.	-2.	3.	7.	3.	7.	0.	2.	-2.	5.	1.	-22.	19.	5.	4.
29	-2.	-6.	-1.	-1.	-2.	-1.	-2.	5.	-1.	8.	-3.	6.	6.	-8.	-1.	1.
30	7.	7.	0.	-2.	4.	-4.	-3.	0.	3.	-7.	5.	0.	0.	0.	-4.	0.
31	-2.	-4.	0.	0.	-4.	-2.	7.	5.	3.	-1.	3.	-10.	11.	-6.	0.	-3.
32	2.	-6.	-1.	0.	9.	6.	6.	-2.	1.	0.	4.	3.	-14.	0.	8.	-4.
33	3.	-3.	3.	0.	12.	2.	6.	-1.	7.	3.	8.	0.	14.	6.	-6.	6.
34	4.	2.	-3.	-5.	-1.	-5.	1.	-3.	3.	-6.	6.	-7.	-2.	-6.	5.	-9.
35	5.	-4.	3.	-2.	8.	-6.	14.	5.	11.	0.	10.	-1.	-1.	-5.	5.	-7.
36	-2.	-5.	-3.	2.	4.	-1.	0.	-7.	7.	-7.	10.	-5.	27.	-2.	4.	-1.
37	-1.	-4.	3.	-2.	9.	-4.	23.	9.	12.	1.	14.	5.	-1.	9.	14.	3.
38	-1.	0.	0.	2.	9.	-9.	4.	-5.	10.	7.	10.	-7.	15.	-17.	6.	1.
39	-4.	-3.	-3.	7.	6.	2.	17.	1.	21.	2.	19.	12.	14.	-3.	14.	-1.
40	12.	7.	2.	-5.	8.	14.	5.	-6.	13.	3.	19.	-4.	20.	24.	13.	1.
41	-5.	0.	1.	2.	14.	-5.	8.	8.	22.	-8.	22.	1.	21.	-10.	16.	-6.
42	13.	6.	0.	0.	8.	9.	11.	2.	17.	8.	19.	-4.	8.	-1.	8.	-1.
43	4.	2.	-4.	-3.	17.	-7.	17.	7.	20.	-2.	21.	-1.	25.	-1.	41.	7.
44	-6.	-7.	4.	1.	11.	5.	17.	-3.	24.	3.	27.	0.	15.	-7.	21.	3.
45	0.	1.	-2.	-2.	11.	-8.	23.	-9.	23.	-8.	25.	-2.	37.	10.	23.	-16.
46	-8.	1.	2.	0.	27.	7.	11.	2.	28.	1.	30.	0.	14.	-20.	31.	2.
47	-3.	2.	0.	-4.	9.	-4.	26.	3.	26.	-4.	29.	1.	23.	9.	13.	0.
48	-1.	2.	-3.	0.	16.	3.	15.	-7.	25.	2.	27.	0.	26.	-3.	29.	-3.
49	-2.	5.	3.	-4.	15.	-9.	16.	3.	25.	-5.	31.	-4.	38.	8.	29.	-8.
50	0.	3.	0.	3.	16.	11.	23.	5.	30.	3.	39.	9.	18.	-21.	34.	-11.
51	1.	-5.	3.	3.	15.	9.	25.	-6.	29.	3.	36.	-4.	23.	7.	38.	2.
52	-5.	1.	-5.	1.	17.	-3.	18.	-3.	26.	4.	41.	5.	41.	5.	41.	4.
53	-4.	5.	1.	-5.	7.	-4.	11.	-2.	24.	2.	36.	1.	24.	-4.	21.	-15.

54	-3.	1.	1.	4.	17.	1.	12.	-1.	33.	-4.	39.	6.	39.	1.	44.	1.
55	-9.	-6.	1.	5.	15.	-2.	21.	-1.	19.	0.	47.	3.	26.	-16.	51.	6.
56	-5.	7.	-3.	-2.	14.	5.	14.	1.	17.	6.	46.	8.	37.	10.	43.	-8.
57	-5.	2.	-3.	4.	11.	0.	0.	-6.	14.	5.	38.	8.	25.	-4.	24.	-4.
58	3.	-1.	-3.	1.	7.	7.	9.	-3.	33.	-1.	37.	8.	22.	7.	51.	11.
59	-9.	-11.	2.	1.	7.	0.	14.	0.	16.	3.	48.	5.	30.	-1.	32.	-21.
60	4.	-5.	-2.	5.	10.	3.	-2.	1.	9.	3.	43.	12.	23.	-22.	32.	-17.
61	5.	11.	0.	-7.	7.	4.	3.	-6.	-2.	0.	45.	1.	5.	-2.	35.	-9.
62	5.	12.	0.	2.	-2.	-1.	-2.	1.	-3.	-5.	36.	10.	9.	-2.	18.	-21.
63	-1.	4.	-4.	-6.	3.	-4.	-3.	-3.	1.	2.	35.	9.	7.	-9.	21.	-18.
64	7.	-14.	4.	2.	-1.	-8.	-6.	10.	-1.	-3.	44.	15.	11.	-16.	-2.	-20.
65	3.	-4.	-1.	-2.	-2.	-3.	-6.	-4.	-2.	-4.	45.	16.	10.	-16.	39.	-32.
66	0.	1.	1.	3.	-5.	5.	-3.	4.	-8.	-1.	43.	11.	2.	4.	18.	-25.
67	-8.	5.	-3.	-2.	-4.	-5.	-9.	-6.	0.	-8.	42.	23.	8.	-24.	34.	-42.
68	-4.	10.	2.	1.	-7.	0.	-9.	-2.	3.	8.	45.	24.	17.	3.	31.	-21.
69	-9.	-8.	0.	5.	-5.	3.	-15.	2.	1.	0.	46.	24.	10.	-16.	33.	-28.
70	-7.	-2.	-3.	-2.	-8.	5.	-12.	3.	0.	-3.	38.	20.	3.	-24.	30.	-43.
71	-1.	-1.	2.	0.	-8.	-2.	-8.	5.	-14.	-3.	34.	27.	6.	3.	17.	-35.
72	1.	3.	-1.	0.	-7.	-2.	-10.	-5.	-5.	-10.	36.	30.	-4.	-18.	22.	-40.
73	1.	9.	-2.	-4.	-14.	-10.	-18.	3.	-7.	-16.	32.	27.	6.	-10.	-14.	-155.
74	4.	-1.	7.	-1.	-2.	0.	-6.	8.	-9.	-1.	31.	26.	-1.	-22.	56.	57.
75	0.	-3.	0.	0.	-7.	3.	-22.	1.	-12.	-7.	30.	33.	0.	-13.	17.	-42.
76	2.	-8.	-2.	-2.	-16.	-6.	-5.	3.	-2.	-8.	32.	27.	5.	0.	23.	-46.
77	-1.	11.	2.	8.	-4.	1.	-21.	5.	-11.	-13.	19.	33.	-7.	-18.	-20.	-35.
78	-3.	-1.	-1.	-1.	-13.	4.	-12.	7.	-6.	0.	18.	34.	15.	9.	20.	-36.
79	5.	2.	-4.	-1.	0.	-4.	-14.	-3.	-10.	-3.	19.	31.	2.	-17.	19.	-38.
80	-6.	-2.	4.	1.	-8.	-1.	-18.	6.	-7.	-7.	13.	17.	16.	-20.	14.	-36.
81	8.	-4.	-4.	-7.	-15.	2.	-12.	-2.	-13.	-12.	14.	25.	-8.	-8.	1.	-48.
82	7.	-7.	2.	1.	-6.	-5.	-13.	7.	-8.	-4.	5.	25.	4.	-12.	14.	-45.
83	5.	3.	-1.	2.	-8.	2.	-11.	2.	-13.	2.	3.	14.	7.	7.	10.	-32.
84	6.	3.	1.	1.	-13.	-3.	-12.	10.	-10.	-4.	6.	23.	-6.	-12.	-4.	-14.
85	-2.	-7.	0.	-1.	-10.	-2.	-16.	9.	-11.	4.	-9.	10.	9.	13.	3.	-18.
86	5.	6.	0.	1.	-13.	-3.	-17.	13.	-14.	-1.	-6.	9.	6.	-13.	-13.	-12.
87	3.	1.	-2.	-6.	-6.	-4.	-4.	3.	-9.	-1.	-7.	4.	-1.	-1.	-5.	-18.
88	-7.	-1.	2.	-1.	-3.	1.	-9.	8.	-2.	9.	-5.	24.	17.	9.	8.	-9.
89	0.	-3.	-3.	0.	-7.	2.	-15.	16.	0.	12.	-9.	10.	1.	1.	12.	-5.
90	-3.	-7.	1.	2.	-4.	10.	-3.	19.	0.	17.	0.	2.	11.	11.	10.	10.
91	-7.	6.	1.	5.	-4.	-7.	-14.	5.	4.	10.	-10.	9.	14.	-4.	8.	-6.
92	-1.	-5.	4.	-1.	-1.	6.	-4.	18.	1.	7.	-9.	2.	15.	1.	10.	13.
93	3.	5.	0.	3.	-5.	-6.	-15.	17.	-2.	23.	-23.	2.	6.	5.	8.	11.
94	3.	3.	0.	-2.	-2.	8.	-13.	10.	-3.	16.	-11.	-5.	5.	12.	4.	2.
95	-6.	-2.	1.	0.	1.	-1.	-1.	12.	2.	6.	-12.	13.	12.	15.	18.	-1.
96	8.	-2.	-4.	0.	-6.	1.	-13.	11.	-3.	19.	-17.	-11.	2.	-2.	-2.	6.
97	-3.	2.	-2.	-1.	0.	6.	1.	5.	5.	21.	-18.	2.	6.	19.	16.	22.
98	2.	9.	3.	-2.	2.	4.	-10.	8.	-1.	11.	-12.	2.	8.	-2.	7.	12.
99	2.	-1.	0.	2.	-1.	4.	1.	13.	4.	20.	-19.	-3.	-1.	6.	5.	8.
100	2.	-4.	-2.	3.	-3.	8.	-7.	9.	2.	18.	-18.	2.	20.	1.	10.	17.
101	-4.	0.	-4.	-1.	-2.	2.	-7.	10.	4.	16.	-26.	-1.	3.	7.	17.	13.
102	2.	3.	3.	0.	4.	1.	4.	7.	16.	16.	-1.	-6.	1.	13.	8.	-9.
103	-4.	-5.	0.	-2.	-1.	7.	-7.	9.	-12.	8.	-16.	-3.	15.	11.	1.	35.
104	-2.	5.	-5.	1.	-6.	1.	6.	7.	-5.	19.	-13.	-3.	1.	7.	4.	29.
105	-6.	5.	3.	0.	0.	4.	-8.	4.	4.	18.	-25.	-6.	2.	1.	2.	0.
106	0.	-5.	1.	1.	-4.	4.	-6.	4.	4.	-2.	-13.	3.	7.	-3.	1.	6.
107	-3.	0.	1.	0.	2.	8.	6.	11.	-4.	13.	-22.	-3.	-4.	28.	-4.	24.
108	-4.	-1.	-2.	-2.	-3.	1.	-13.	4.	5.	3.	-16.	-4.	-3.	0.	-2.	33.
109	2.	1.	0.	-1.	0.	-1.	1.	10.	0.	10.	-12.	-4.	3.	6.	4.	7.
110	-2.	-6.	1.	2.	-9.	6.	0.	5.	-5.	4.	-11.	3.	2.	5.	-5.	18.
111	-3.	-2.	0.	0.	6.	12.	-9.	14.	3.	-2.	-16.	3.	2.	-3.	-3.	15.
112	0.	1.	0.	0.	-10.	-2.	-2.	4.	1.	12.	-15.	-1.	-7.	12.	0.	18.
113	-1.	4.	1.	-1.	-1.	-3.	-3.	2.	-6.	4.	-13.	-5.	0.	-4.	-1.	24.
114	1.	0.	-1.	-1.	-4.	3.	-6.	9.	-14.	10.	-12.	8.	5.	8.	-12.	14.
115	-1.	6.	2.	1.	-8.	3.	-5.	1.	-7.	-2.	-13.	3.	-8.	13.	-2.	11.
116	0.	-4.	-2.	0.	-3.	4.	2.	13.	3.	8.	-6.	8.	3.	0.	1.	24.
117	0.	-6.	-1.	1.	-6.	7.	-3.	5.	-10.	5.	-10.	4.	-20.	5.	-9.	14.
118	0.	1.	3.	1.	-4.	-1.	-3.	8.	-9.	-5.	-7.	-1.	-2.	4.	-14.	18.
119	1.	0.	-3.	0.	-4.	-5.	-13.	3.	-6.	-2.	-4.	0.	-6.	-4.	-6.	5.

120	5.	0.	1.	2.	-5.	4.	1.	10.	-8.	-6.	-10.	4.	5.	-6.	-7.	3.
121	2.	-6.	-1.	-1.	-6.	4.	2.	11.	-2.	5.	-5.	5.	-11.	28.	-22.	14.
122	4.	-1.	1.	-2.	-1.	4.	-9.	2.	-2.	8.	2.	5.	-11.	-18.	-14.	16.
123	6.	0.	-1.	3.	-4.	4.	-6.	7.	-8.	4.	-5.	6.	-6.	23.	-6.	13.
124	-7.	3.	1.	-1.	-9.	-10.	-5.	1.	-3.	-17.	-7.	2.	1.	-12.	-3.	-8.
125	5.	1.	3.	-2.	-3.	2.	0.	7.	-13.	4.	-7.	-2.	-16.	-2.	-31.	17.
126	7.	3.	0.	0.	-3.	-1.	7.	11.	7.	2.	3.	12.	-9.	16.	2.	0.
127	-8.	-1.	7.	5.	-1.	8.	-3.	7.	0.	-7.	6.	3.	-1.	4.	-3.	8.
128	1.	-2.	-3.	0.	-8.	-11.	-6.	1.	-9.	-3.	-8.	3.	-5.	-8.	-10.	15.
129	-4.	0.	2.	-1.	0.	9.	-1.	9.	-5.	0.	0.	15.	-12.	23.	-15.	0.
130	2.	4.	-8.	-2.	0.	-2.	-6.	0.	-8.	-14.	-1.	-2.	-11.	-16.	-14.	-1.
131	9.	-4.	1.	1.	-6.	-3.	-5.	12.	-6.	2.	-9.	1.	-5.	7.	-8.	11.
132	-4.	-1.	-1.	1.	3.	3.	7.	4.	-6.	-2.	1.	-3.	-15.	0.	18.	6.
133	-4.	-1.	1.	0.	-1.	-4.	-3.	-3.	-5.	1.	-3.	4.	-4.	8.	-35.	0.
134	0.	2.	2.	-6.	-3.	-5.	6.	9.	-7.	-14.	3.	-6.	-12.	-10.	-16.	8.
135	0.	5.	0.	1.	3.	-3.	-6.	-5.	-12.	-11.	-2.	3.	-23.	4.	-16.	-6.
136	1.	-5.	3.	-3.	5.	3.	4.	5.	-1.	1.	-3.	1.	-1.	7.	-5.	10.
137	-2.	-2.	-5.	3.	-4.	-3.	5.	6.	-11.	9.	-2.	8.	-13.	3.	-19.	15.
138	-1.	1.	1.	-5.	5.	1.	3.	0.	-6.	-10.	-3.	3.	-7.	9.	1.	1.
139	0.	1.	2.	7.	-1.	0.	2.	0.	-8.	-2.	3.	6.	-3.	-2.	-6.	0.
140	-3.	-2.	-3.	0.	2.	-1.	-5.	10.	-8.	5.	-4.	4.	-5.	0.	-5.	8.
141	1.	1.	-2.	-7.	3.	-5.	-4.	-18.	-7.	-9.	-4.	-11.	-16.	2.	-28.	9.
142	-1.	4.	1.	2.	8.	-2.	5.	4.	-8.	-4.	-2.	6.	-11.	5.	-12.	6.
143	-12.	0.	6.	3.	5.	-4.	1.	-7.	1.	-5.	-3.	-9.	-4.	-8.	1.	5.
144	4.	-5.	0.	0.	5.	-1.	9.	2.	-9.	-1.	-3.	4.	-12.	3.	-26.	11.
145	-6.	5.	-5.	-3.	-2.	0.	-1.	3.	-10.	5.	-6.	-1.	-6.	14.	-6.	11.
146	6.	-3.	2.	5.	3.	2.	-13.	-9.	-10.	-1.	4.	4.	-17.	8.	-24.	1.
147	-2.	-4.	-2.	0.	7.	-3.	13.	-4.	-10.	-15.	-8.	-17.	-19.	-22.	-17.	-3.
148	-2.	0.	0.	-2.	0.	-4.	-5.	-3.	-8.	12.	-7.	-7.	5.	13.	-1.	20.
149	-2.	4.	-2.	2.	8.	-1.	-7.	-5.	4.	-5.	-1.	3.	-13.	4.	-15.	3.
150	-3.	-3.	5.	-7.	0.	-3.	11.	-15.	-4.	-5.	5.	-4.	8.	5.	-6.	1.

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

THE FOLLOWING IS A LISTING OF PARAMETER - SLED DISPLACEMENT IN FEET:

FRAME	TIME	HIP		KNEE		SHOULDER		ELBOW		HEAD PT. 1		HEAD PT. 2	
NO.	(SEC)	X	Z	X	Z	X	Z	X	Z	X	Z	X	Z
5	.01020	-.055	.305	1.509	.375	-.500	2.005	-.366	.898	-.539	2.574	-.246	3.076
6	.01224	-.055	.305	1.510	.375	-.500	2.005	-.366	.899	-.540	2.574	-.249	3.079
7	.01428	-.055	.305	1.512	.375	-.499	2.007	-.365	.901	-.540	2.576	-.253	3.083
8	.01632	-.055	.305	1.513	.375	-.499	2.008	-.365	.902	-.539	2.578	-.257	3.085
9	.01836	-.055	.305	1.513	.375	-.498	2.010	-.365	.903	-.538	2.579	-.264	3.087
10	.02040	-.055	.305	1.513	.375	-.499	2.010	-.366	.904	-.538	2.580	-.270	3.090
11	.02244	-.056	.304	1.513	.374	-.499	2.011	-.366	.904	-.538	2.581	-.275	3.091
12	.02448	-.056	.304	1.511	.375	-.499	2.010	-.366	.904	-.537	2.580	-.279	3.091
13	.02652	-.056	.304	1.510	.376	-.500	2.010	-.366	.903	-.538	2.580	-.280	3.093
14	.02856	-.056	.304	1.509	.376	-.500	2.009	-.366	.903	-.538	2.579	-.279	3.092
15	.03060	-.056	.304	1.509	.376	-.500	2.008	-.366	.902	-.538	2.579	-.280	3.091
16	.03264	-.056	.303	1.509	.375	-.500	2.006	-.365	.901	-.541	2.577	-.278	3.089
17	.03468	-.056	.304	1.509	.374	-.499	2.007	-.365	.902	-.541	2.577	-.277	3.089
18	.03672	-.056	.304	1.510	.373	-.499	2.007	-.365	.901	-.539	2.576	-.277	3.088
19	.03876	-.056	.304	1.511	.372	-.499	2.007	-.365	.901	-.537	2.576	-.277	3.088
20	.04080	-.055	.304	1.512	.372	-.499	2.007	-.366	.902	-.535	2.575	-.277	3.088
21	.04284	-.055	.305	1.513	.372	-.498	2.007	-.366	.903	-.534	2.575	-.278	3.088
22	.04488	-.054	.305	1.513	.373	-.498	2.008	-.365	.903	-.534	2.576	-.279	3.089
23	.04692	-.054	.306	1.513	.375	-.498	2.009	-.365	.904	-.534	2.576	-.281	3.090
24	.04896	-.054	.306	1.514	.375	-.498	2.009	-.365	.904	-.534	2.576	-.281	3.090
25	.05100	-.054	.307	1.514	.375	-.499	2.008	-.365	.904	-.536	2.576	-.282	3.090
26	.05304	-.053	.307	1.514	.375	-.500	2.008	-.364	.904	-.539	2.577	-.282	3.090
27	.05508	-.053	.307	1.514	.376	-.500	2.008	-.364	.904	-.540	2.577	-.283	3.091
28	.05712	-.053	.307	1.514	.377	-.500	2.007	-.363	.903	-.540	2.577	-.283	3.090
29	.05916	-.051	.307	1.516	.378	-.499	2.007	-.362	.903	-.540	2.577	-.282	3.090
30	.06120	-.049	.308	1.517	.378	-.499	2.006	-.361	.903	-.539	2.577	-.282	3.090
31	.06324	-.047	.309	1.519	.380	-.497	2.006	-.359	.903	-.540	2.577	-.281	3.090
32	.06528	-.044	.309	1.521	.381	-.495	2.007	-.356	.903	-.539	2.577	-.281	3.089
33	.06731	-.042	.309	1.525	.382	-.492	2.006	-.352	.902	-.536	2.576	-.280	3.088
34	.06935	-.038	.309	1.528	.383	-.489	2.006	-.348	.901	-.534	2.577	-.278	3.087
35	.07139	-.034	.307	1.534	.383	-.485	2.006	-.343	.900	-.530	2.575	-.275	3.086
36	.07343	-.030	.306	1.540	.383	-.479	2.006	-.337	.900	-.525	2.574	-.271	3.085
37	.07547	-.026	.303	1.546	.382	-.472	2.006	-.330	.900	-.517	2.573	-.265	3.085
38	.07751	-.022	.302	1.552	.382	-.465	2.005	-.321	.899	-.509	2.572	-.259	3.083
39	.07955	-.017	.301	1.559	.381	-.455	2.005	-.312	.899	-.498	2.572	-.251	3.082
40	.08159	-.011	.302	1.565	.382	-.446	2.006	-.301	.899	-.488	2.571	-.241	3.082
41	.08363	-.005	.303	1.572	.383	-.435	2.007	-.290	.899	-.477	2.572	-.230	3.082
42	.08567	.003	.305	1.579	.383	-.423	2.008	-.277	.898	-.464	2.572	-.215	3.082
43	.08771	.010	.307	1.588	.385	-.410	2.008	-.263	.898	-.451	2.573	-.200	3.081
44	.08975	.019	.307	1.598	.385	-.397	2.007	-.249	.898	-.438	2.571	-.184	3.081
45	.09179	.028	.306	1.610	.385	-.382	2.006	-.234	.897	-.423	2.569	-.167	3.080
46	.09383	.038	.306	1.621	.384	-.367	2.006	-.218	.897	-.407	2.568	-.150	3.079
47	.09587	.047	.305	1.633	.384	-.352	2.004	-.202	.897	-.391	2.566	-.133	3.075
48	.09791	.057	.306	1.645	.382	-.336	2.003	-.184	.896	-.374	2.564	-.115	3.072
49	.09995	.066	.306	1.657	.382	-.320	2.003	-.164	.896	-.357	2.563	-.094	3.068
50	.10199	.075	.308	1.669	.381	-.304	2.003	-.145	.897	-.339	2.563	-.074	3.065
51	.10403	.083	.308	1.681	.380	-.287	2.003	-.124	.897	-.320	2.562	-.051	3.062
52	.10607	.093	.308	1.692	.379	-.271	2.004	-.101	.898	-.299	2.560	-.024	3.059
53	.10811	.101	.308	1.703	.378	-.256	2.004	-.077	.900	-.279	2.558	.001	3.056
54	.11015	.110	.308	1.712	.375	-.241	2.004	-.053	.901	-.258	2.555	.028	3.055

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT G 2, RUN1039, 751117, NYLON 11 POINT QUADRATIC FIT

THE FOLLOWING IS A LISTING OF PARAMETER - SLED DISPLACEMENT IN FEET:

FRAME	TIME	HIP		KNEE		SHOULDER		ELBOW		HEAD PT. 1		HEAD PT. 2	
NO.	(SEC)	X	Z	X	Z	X	Z	X	Z	X	Z	X	Z
55	.11219	.118	.307	1.721	.373	-.227	2.005	-.029	.903	-.237	2.556	.056	3.055
56	.11423	.126	.306	1.727	.371	-.213	2.005	-.004	.906	-.216	2.554	.083	3.052
57	.11627	.133	.306	1.734	.368	-.201	2.005	.021	.909	-.197	2.551	.111	3.048
58	.11831	.139	.307	1.739	.366	-.191	2.005	.046	.912	-.180	2.548	.138	3.043
59	.12035	.145	.309	1.743	.364	-.182	2.006	.071	.915	-.165	2.546	.164	3.037
60	.12239	.149	.310	1.745	.363	-.176	2.007	.095	.920	-.153	2.544	.184	3.029
61	.12443	.152	.310	1.746	.362	-.172	2.007	.119	.925	-.144	2.538	.202	3.019
62	.12647	.154	.311	1.746	.364	-.171	2.007	.144	.930	-.136	2.534	.219	3.008
63	.12851	.155	.310	1.744	.365	-.173	2.007	.168	.937	-.131	2.527	.232	2.993
64	.13055	.155	.310	1.742	.366	-.175	2.006	.192	.945	-.126	2.522	.246	2.978
65	.13259	.153	.308	1.738	.366	-.177	2.005	.216	.954	-.121	2.517	.260	2.962
66	.13463	.151	.306	1.734	.366	-.177	2.004	.242	.964	-.115	2.509	.277	2.942
67	.13667	.148	.306	1.728	.366	-.178	2.003	.268	.975	-.108	2.501	.297	2.921
68	.13871	.144	.306	1.723	.365	-.179	2.002	.293	.986	-.103	2.493	.319	2.904
69	.14075	.141	.306	1.717	.364	-.179	2.001	.318	.999	-.097	2.486	.338	2.874
70	.14279	.136	.306	1.711	.364	-.181	1.998	.341	1.014	-.093	2.478	.355	2.843
71	.14483	.132	.305	1.702	.365	-.184	1.996	.363	1.029	-.089	2.469	.370	2.813
72	.14687	.126	.305	1.695	.368	-.188	1.994	.383	1.046	-.088	2.462	.387	2.783
73	.14891	.121	.304	1.687	.370	-.193	1.989	.402	1.062	-.088	2.452	.399	2.751
74	.15095	.115	.303	1.678	.373	-.199	1.984	.420	1.080	-.089	2.446	.409	2.722
75	.15299	.109	.302	1.670	.375	-.205	1.979	.436	1.098	-.089	2.440	.419	2.695
76	.15503	.104	.301	1.660	.377	-.209	1.974	.451	1.115	-.087	2.432	.430	2.670
77	.15707	.099	.300	1.651	.379	-.214	1.970	.465	1.133	-.085	2.425	.439	2.648
78	.15911	.094	.300	1.643	.380	-.219	1.966	.477	1.150	-.082	2.418	.449	2.628
79	.16115	.090	.300	1.634	.382	-.223	1.962	.488	1.166	-.077	2.412	.455	2.595
80	.16319	.085	.300	1.626	.383	-.228	1.959	.496	1.182	-.074	2.405	.462	2.567
81	.16523	.081	.300	1.617	.386	-.234	1.956	.503	1.196	-.072	2.400	.469	2.541
82	.16727	.075	.300	1.609	.389	-.240	1.955	.507	1.209	-.069	2.396	.477	2.518
83	.16931	.068	.298	1.601	.392	-.247	1.953	.509	1.219	-.068	2.391	.479	2.497
84	.17135	.061	.298	1.593	.397	-.255	1.952	.509	1.228	-.066	2.390	.478	2.473
85	.17339	.056	.296	1.585	.402	-.261	1.952	.507	1.238	-.064	2.390	.478	2.465
86	.17543	.050	.296	1.578	.408	-.267	1.954	.504	1.245	-.061	2.391	.477	2.456
87	.17747	.046	.296	1.571	.415	-.271	1.958	.501	1.253	-.057	2.393	.477	2.450
88	.17951	.042	.297	1.565	.422	-.273	1.962	.498	1.259	-.052	2.394	.479	2.446
89	.18155	.039	.297	1.560	.430	-.274	1.967	.494	1.265	-.045	2.396	.483	2.443
90	.18359	.036	.298	1.553	.437	-.274	1.974	.489	1.268	-.039	2.396	.488	2.443
91	.18563	.033	.298	1.547	.445	-.274	1.981	.483	1.272	-.033	2.400	.495	2.445
92	.18767	.031	.298	1.539	.453	-.275	1.989	.476	1.273	-.026	2.401	.501	2.447
93	.18971	.028	.298	1.534	.461	-.275	1.996	.468	1.272	-.021	2.404	.507	2.450
94	.19175	.027	.298	1.528	.468	-.275	2.005	.460	1.273	-.015	2.409	.512	2.455
95	.19379	.026	.299	1.523	.475	-.275	2.014	.451	1.273	-.011	2.415	.518	2.460
96	.19583	.025	.302	1.519	.482	-.275	2.024	.442	1.274	-.007	2.421	.523	2.467
97	.19786	.025	.304	1.515	.488	-.275	2.034	.433	1.274	-.002	2.425	.530	2.475
98	.19990	.025	.307	1.514	.494	-.272	2.044	.424	1.274	.003	2.429	.537	2.481
99	.20194	.025	.309	1.511	.499	-.269	2.054	.414	1.273	.008	2.433	.544	2.488
100	.20398	.026	.312	1.509	.505	-.267	2.064	.405	1.272	.013	2.437	.550	2.498
101	.20602	.026	.314	1.508	.510	-.265	2.073	.397	1.271	.018	2.442	.557	2.508
102	.20806	.025	.316	1.507	.515	-.263	2.082	.388	1.269	.024	2.444	.562	2.517
103	.21010	.025	.318	1.506	.520	-.262	2.091	.379	1.267	.028	2.450	.567	2.525
104	.21214	.024	.321	1.505	.524	-.262	2.098	.370	1.266	.032	2.455	.570	2.536

DATE: 9 JUN 77 TEST NUMBER: 1039

RSO STUDY, SUBJECT C 2, RUN1033, 761117, NYLON 11 POINT QUADRATIC FIT

THE FOLLOWING IS A LISTING OF PARAMETER - SLED DISPLACEMENT IN FEET:

FRAME	TIME	HIP		KNEE		SHOULDER		ELBOW		HEAD PT.1		HEAD PT. 2	
NO.	(SEC)	X	Z	X	Z	X	Z	X	Z	X	Z	X	Z
105	.21418	.024	.323	1.503	.528	-.262	2.105	.360	1.264	.033	2.461	.572	2.547
106	.21622	.022	.325	1.502	.532	-.262	2.112	.351	1.262	.034	2.466	.573	2.560
107	.21826	.021	.328	1.500	.536	-.263	2.116	.340	1.261	.035	2.470	.574	2.573
108	.22030	.020	.331	1.498	.541	-.261	2.120	.331	1.260	.035	2.474	.574	2.582
109	.22234	.018	.333	1.495	.545	-.261	2.123	.322	1.259	.034	2.478	.574	2.594
110	.22438	.017	.336	1.493	.551	-.261	2.126	.314	1.259	.035	2.482	.573	2.608
111	.22642	.015	.337	1.491	.555	-.263	2.130	.305	1.259	.034	2.485	.571	2.621
112	.22846	.013	.339	1.488	.559	-.265	2.133	.298	1.260	.035	2.487	.569	2.632
113	.23050	.010	.340	1.486	.563	-.267	2.136	.290	1.261	.034	2.490	.567	2.643
114	.23254	.007	.343	1.484	.567	-.271	2.139	.282	1.263	.032	2.494	.564	2.656
115	.23458	.004	.344	1.481	.571	-.274	2.143	.276	1.265	.029	2.498	.561	2.669
116	.23662	.001	.344	1.479	.574	-.279	2.144	.271	1.267	.026	2.499	.557	2.680
117	.23866	-.002	.345	1.477	.578	-.283	2.144	.266	1.268	.024	2.502	.553	2.688
118	.24070	-.005	.346	1.475	.583	-.287	2.144	.261	1.270	.020	2.503	.547	2.696
119	.24274	-.007	.347	1.474	.587	-.290	2.144	.258	1.271	.015	2.505	.540	2.705
120	.24478	-.009	.348	1.471	.591	-.292	2.144	.256	1.273	.013	2.506	.533	2.712
121	.24682	-.012	.349	1.467	.594	-.297	2.143	.252	1.274	.009	2.508	.524	2.718
122	.24886	-.015	.349	1.465	.598	-.300	2.143	.250	1.276	.005	2.510	.515	2.724
123	.25090	-.018	.350	1.463	.603	-.302	2.144	.247	1.279	-.000	2.513	.507	2.729
124	.25294	-.021	.350	1.461	.606	-.305	2.143	.245	1.281	-.006	2.514	.498	2.735
125	.25498	-.025	.350	1.459	.610	-.308	2.143	.242	1.284	-.012	2.517	.490	2.741
126	.25702	-.029	.349	1.457	.612	-.312	2.140	.241	1.287	-.017	2.518	.484	2.744
127	.25906	-.032	.348	1.455	.616	-.315	2.137	.239	1.290	-.022	2.521	.475	2.747
128	.26110	-.034	.349	1.454	.620	-.317	2.135	.238	1.292	-.028	2.522	.469	2.752
129	.26314	-.034	.349	1.453	.623	-.320	2.133	.237	1.295	-.033	2.525	.465	2.756
130	.26518	-.035	.349	1.452	.627	-.322	2.131	.237	1.297	-.037	2.526	.461	2.759
131	.26722	-.036	.348	1.451	.629	-.326	2.128	.236	1.297	-.043	2.526	.454	2.763
132	.26926	-.035	.348	1.451	.632	-.329	2.126	.235	1.298	-.049	2.528	.447	2.765
133	.27130	-.035	.348	1.451	.635	-.333	2.124	.234	1.299	-.057	2.529	.438	2.768
134	.27334	-.035	.347	1.452	.638	-.337	2.122	.233	1.299	-.064	2.530	.429	2.773
135	.27538	-.036	.347	1.453	.640	-.342	2.121	.231	1.301	-.073	2.534	.420	2.777
136	.27742	-.035	.346	1.454	.642	-.347	2.119	.231	1.303	-.079	2.536	.412	2.780
137	.27946	-.035	.346	1.455	.644	-.351	2.118	.230	1.305	-.085	2.538	.404	2.784
138	.28150	-.033	.346	1.456	.646	-.356	2.117	.230	1.308	-.090	2.541	.398	2.789
139	.28354	-.031	.345	1.456	.645	-.359	2.116	.229	1.309	-.095	2.543	.393	2.792
140	.28558	-.030	.344	1.457	.645	-.363	2.115	.228	1.309	-.100	2.543	.386	2.797
141	.28762	-.028	.343	1.458	.644	-.367	2.113	.226	1.309	-.105	2.543	.379	2.801
142	.28966	-.026	.342	1.457	.643	-.371	2.111	.224	1.309	-.111	2.546	.371	2.806
143	.29170	-.023	.340	1.458	.641	-.376	2.109	.223	1.308	-.118	2.546	.360	2.810
144	.29374	-.021	.339	1.459	.639	-.381	2.108	.220	1.307	-.126	2.548	.349	2.816
145	.29578	-.019	.338	1.459	.637	-.385	2.106	.218	1.304	-.134	2.548	.339	2.820

THE ABOVE DATA WAS PLOTTED (X VERSUS Z) FOR FRAME NUMBER 5 TO FRAME NUMBER 145

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1033, 761117, NYLON 11 POINT QUADRATIC FIT

THE FOLLOWING IS A LISTING OF THE ANGULAR MOTION OF THE HEAD AND SHOULDER:

	SHOULDER - HIP				HEAD PT. 1 - HEAD PT. 2		
FRAME NO.	TIME (SEC)	THETA (RADIANS)	W (RAD/SEC)	W-ACC (RAD/SEC SQ)	THETA (RADIANS)	W (RAD/SEC)	W-ACC (RAD/SEC SQ)
15	.03060	1.826	.009	3.238	4.245	.314	-123.689
16	.03264	1.826	.015	3.559	4.238	.183	-71.885
17	.03468	1.826	.011	4.948	4.237	.225	-30.479
18	.03672	1.826	.017	6.848	4.239	.498	-5.766
19	.03876	1.825	.019	8.727	4.242	.785	.313
20	.04080	1.825	.045	10.361	4.246	.897	-9.816
21	.04284	1.826	.089	11.615	4.250	.874	-30.971
22	.04488	1.826	.131	12.300	4.251	.660	-54.315
23	.04692	1.826	.157	11.838	4.256	.359	-72.928
24	.04896	1.826	.175	9.996	4.256	.058	-78.107
25	.05100	1.827	.194	6.764	4.253	-.189	-67.430
26	.05304	1.828	.216	2.230	4.248	-.393	-45.350
27	.05508	1.828	.225	-3.326	4.248	-.476	-16.652
28	.05712	1.828	.220	-10.365	4.247	-.446	13.359
29	.05916	1.829	.205	-19.079	4.247	-.305	40.800
30	.06120	1.829	.167	-29.094	4.247	-.096	62.406
31	.06324	1.830	.108	-39.750	4.245	.103	75.077
32	.06528	1.830	.021	-49.796	4.246	.268	75.808
33	.06731	1.830	-.109	-58.457	4.249	.463	63.996
34	.06935	1.830	-.264	-64.906	4.248	.670	42.411
35	.07139	1.830	-.428	-68.230	4.249	.831	13.715
36	.07343	1.829	-.601	-68.239	4.251	.881	-18.547
37	.07547	1.827	-.757	-65.068	4.255	.804	-52.677
38	.07751	1.825	-.901	-59.511	4.257	.580	-85.525
39	.07955	1.823	-1.022	-53.306	4.261	.316	-114.251
40	.08159	1.821	-1.111	-46.762	4.262	-.015	-134.868
41	.08363	1.818	-1.181	-41.813	4.260	-.370	-146.104
42	.08567	1.816	-1.236	-38.964	4.259	-.749	-151.439
43	.08771	1.813	-1.294	-37.640	4.254	-1.061	-152.442
44	.08975	1.811	-1.358	-37.296	4.251	-1.376	-153.746
45	.09179	1.808	-1.433	-37.115	4.249	-1.628	-156.628
46	.09383	1.805	-1.528	-36.351	4.247	-1.859	-161.180
47	.09587	1.802	-1.636	-34.047	4.243	-2.193	-167.862
48	.09791	1.798	-1.723	-29.095	4.239	-2.521	-178.070
49	.09995	1.795	-1.788	-20.847	4.233	-2.931	-191.741
50	.10199	1.791	-1.828	-9.059	4.227	-3.387	-207.970
51	.10403	1.786	-1.855	5.722	4.220	-3.800	-222.968
52	.10607	1.782	-1.852	22.395	4.209	-4.231	-234.342
53	.10811	1.779	-1.801	40.248	4.201	-4.706	-244.451
54	.11015	1.775	-1.697	58.553	4.191	-5.270	-252.862
55	.11219	1.772	-1.542	75.783	4.181	-5.860	-262.048
56	.11423	1.768	-1.353	89.592	4.171	-6.399	-273.047
57	.11627	1.765	-1.139	97.451	4.158	-6.912	-284.622
58	.11831	1.763	-.878	97.962	4.142	-7.466	-296.547
59	.12035	1.761	-.601	90.873	4.122	-8.051	-316.581
60	.12239	1.760	-.348	76.897	4.105	-8.699	-350.725
61	.12443	1.760	-.165	57.856	4.089	-9.387	-397.080
62	.12647	1.760	-.067	35.824	4.071	-10.117	-451.762
63	.12851	1.762	-.043	13.910	4.052	-10.880	-507.644
64	.13055	1.763	-.084	-3.899	4.029	-12.003	-556.958

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

THE FOLLOWING IS A LISTING OF THE ANGULAR MOTION OF THE HEAD AND SHOULDER:

		SHOULDER - HIP			HEAD PT. 1 - HEAD PT. 2		
FRAME NO.	TIME (SEC)	THETA (RADIANS)	W (RAD/SEC)	W-ACC (RAD/SEC SQ)	THETA (RADIANS)	W (RAD/SEC)	W-ACC (RAD/SEC SQ)
65	.13259	1.763	-.175	-14.743	4.003	-13.408	-591.529
66	.13463	1.761	-.284	-17.632	3.976	-14.885	-601.486
67	.13667	1.760	-.392	-13.639	3.945	-16.417	-576.300
68	.13871	1.759	-.453	-4.705	3.915	-17.858	-508.092
69	.14075	1.757	-.444	6.953	3.869	-19.088	-403.173
70	.14279	1.756	-.376	18.884	3.826	-20.049	-278.699
71	.14483	1.755	-.278	28.817	3.783	-20.565	-150.738
72	.14687	1.755	-.174	35.122	3.736	-20.537	-30.220
73	.14891	1.755	-.073	36.912	3.691	-19.959	72.227
74	.15095	1.755	.020	34.869	3.648	-19.365	150.015
75	.15299	1.756	.094	30.233	3.607	-18.837	200.912
76	.15503	1.756	.148	24.263	3.573	-18.362	228.483
77	.15707	1.756	.181	17.312	3.544	-17.914	244.644
78	.15911	1.757	.202	9.435	3.519	-17.493	267.248
79	.16115	1.757	.221	.614	3.471	-17.085	317.325
80	.16319	1.757	.228	-9.268	3.434	-16.661	389.602
81	.16523	1.758	.222	-20.094	3.397	-16.070	476.951
82	.16727	1.759	.180	-31.125	3.361	-15.166	570.300
83	.16931	1.759	.106	-41.974	3.332	-13.832	657.955
84	.17135	1.760	-.003	-51.345	3.304	-11.951	730.141
85	.17339	1.760	-.148	-57.824	3.280	-10.065	775.077
86	.17543	1.760	-.312	-60.214	3.263	-8.163	783.670
87	.17747	1.759	-.468	-57.744	3.248	-6.329	756.393
88	.17951	1.758	-.622	-51.279	3.238	-4.715	697.214
89	.18155	1.756	-.741	-41.958	3.231	-3.275	617.266
90	.18359	1.754	-.823	-31.114	3.231	-2.144	534.977
91	.18563	1.752	-.858	-20.385	3.228	-1.295	458.171
92	.18767	1.749	-.849	-11.293	3.228	-.541	393.038
93	.18971	1.747	-.833	-4.461	3.228	.049	342.121
94	.19175	1.746	-.819	-.403	3.229	.558	305.297
95	.19379	1.745	-.805	1.637	3.227	1.074	281.731
96	.19583	1.744	-.797	2.495	3.229	1.662	266.213
97	.19786	1.742	-.803	3.706	3.234	2.248	254.886
98	.19990	1.740	-.816	6.057	3.239	2.768	245.136
99	.20194	1.738	-.825	9.198	3.245	3.283	233.282
100	.20398	1.736	-.813	12.749	3.256	3.750	220.808
101	.20602	1.735	-.781	16.621	3.264	4.158	210.246
102	.20806	1.733	-.716	20.478	3.275	4.589	204.351
103	.21010	1.731	-.647	23.673	3.280	4.932	202.070
104	.21214	1.730	-.590	25.807	3.291	5.224	199.520
105	.21418	1.729	-.541	26.925	3.301	5.620	195.078
106	.21622	1.729	-.487	27.661	3.314	6.100	186.473
107	.21826	1.728	-.434	28.631	3.330	6.608	170.565
108	.22030	1.727	-.383	30.577	3.340	7.056	149.411
109	.22234	1.725	-.332	32.942	3.354	7.381	119.088
110	.22438	1.725	-.270	34.811	3.373	7.601	77.922
111	.22642	1.725	-.190	35.832	3.390	7.717	32.650
112	.22846	1.724	-.093	35.744	3.408	7.693	-11.725
113	.23050	1.724	.010	33.916	3.421	7.648	-52.458
114	.23254	1.724	.091	29.939	3.438	7.437	-88.205

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

THE FOLLOWING IS A LISTING OF THE ANGULAR MOTION OF THE HEAD AND SHOULDER:

		SHOULDER - HIP			HEAD PT. 1 - HEAD PT. 2		
FRAME NO.	TIME (SEC)	THETA (RADIANS)	W (RAD/SEC)	W-ACC (RAD/SEC SQ)	THETA (RADIANS)	W (RAD/SEC)	W-ACC (RAD/SEC SQ)
115	.23458	1.724	.148	23.624	3.453	7.101	-118.900
116	.23662	1.725	.199	15.672	3.469	6.817	-144.709
117	.23866	1.725	.232	7.165	3.480	6.521	-165.617
118	.24070	1.726	.234	-.235	3.493	6.159	-183.057
119	.24274	1.727	.211	-5.360	3.506	5.755	-196.935
120	.24478	1.727	.163	-7.955	3.518	5.331	-207.965
121	.24682	1.728	.114	-7.519	3.529	4.876	-215.525
122	.24836	1.728	.071	-3.165	3.540	4.412	-216.960
123	.25090	1.728	.055	4.921	3.546	3.935	-210.148
124	.25294	1.728	.063	15.678	3.555	3.398	-195.997
125	.25498	1.727	.090	27.727	3.560	2.929	-175.375
126	.25702	1.728	.158	39.435	3.566	2.586	-150.315
127	.25906	1.728	.275	49.649	3.569	2.299	-121.739
128	.26110	1.728	.418	57.445	3.575	2.121	-93.004
129	.26314	1.729	.572	62.411	3.576	2.005	-65.917
130	.26518	1.730	.726	64.304	3.579	1.949	-43.045
131	.26722	1.732	.871	62.757	3.586	1.896	-23.606
132	.26926	1.735	1.004	58.582	3.588	1.912	-4.575
133	.27130	1.737	1.126	53.162	3.592	1.884	13.874
134	.27334	1.739	1.223	47.536	3.599	1.876	33.023
135	.27538	1.742	1.315	42.320	3.601	1.920	54.079

THE ABOVE VEL AND ACCEL DATA ARE PLOTTED: YMIN= -2.00 DY= .40 ZMIN= -80.00 DZ= 20.00

THE ABOVE VEL AND ACCEL DATA ARE PLOTTED: YMIN= -28.00 DY= 4.00 ZMIN= -800.00 DZ= 200.00

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

HIP MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
15	.03050	-.001	-.001	.002	.028	-7.061	-.219
16	.03254	-.001	-.002	.002	-.019	-5.713	-.177
17	.03458	-.001	-.001	.001	-.032	-2.754	-.086
18	.03672	-.001	-.002	.002	-.030	.415	.013
19	.03876	-.001	-.001	.001	-.024	4.967	.154
20	.04030	-.000	-.001	.001	-.016	10.425	.324
21	.04284	.000	-.000	.001	.025	16.436	.510
22	.04488	.001	-.000	.001	.070	22.309	.693
23	.04632	.001	.001	.001	.091	28.798	.894
24	.04895	.001	.001	.002	.155	36.117	1.122
25	.05100	.001	.001	.002	.233	44.059	1.368
26	.05304	.002	.002	.003	.332	52.225	1.622
27	.05508	.002	.002	.003	.443	61.046	1.896
28	.05712	.002	.002	.003	.580	69.379	2.155
29	.05916	.004	.002	.005	.736	75.723	2.352
30	.06120	.006	.003	.006	.910	80.949	2.514
31	.06324	.008	.004	.009	1.098	84.843	2.635
32	.06529	.011	.004	.011	1.301	88.288	2.742
33	.06731	.013	.004	.014	1.480	91.660	2.847
34	.06935	.017	.004	.017	1.647	95.600	2.969
35	.07139	.021	.002	.021	1.831	100.663	3.126
36	.07343	.025	.000	.025	2.013	106.909	3.320
37	.07547	.029	-.002	.029	2.230	113.934	3.538
38	.07751	.033	-.003	.033	2.473	121.089	3.761
39	.07955	.038	-.004	.038	2.741	126.464	3.927
40	.08159	.044	-.003	.044	3.036	128.596	3.994
41	.08363	.050	-.002	.050	3.340	126.287	3.922
42	.08567	.058	-.000	.058	3.636	118.556	3.682
43	.08771	.065	.002	.065	3.906	105.893	3.289
44	.08975	.074	.002	.074	4.132	89.146	2.769
45	.09179	.083	.001	.083	4.316	69.381	2.155
46	.09383	.093	.001	.093	4.430	48.147	1.495
47	.09587	.102	.000	.102	4.488	26.808	.833
48	.09791	.112	.001	.112	4.501	6.257	.194
49	.09995	.121	.001	.121	4.481	-13.074	-.406
50	.10199	.130	.003	.130	4.425	-31.201	-.969
51	.10403	.138	.002	.138	4.343	-48.587	-1.509
52	.10607	.148	.003	.148	4.234	-66.777	-2.074
53	.10811	.156	.003	.156	4.093	-86.165	-2.676
54	.11015	.165	.003	.165	3.915	-107.090	-3.326
55	.11219	.173	.002	.173	3.699	-129.302	-4.016
56	.11423	.181	.001	.181	3.426	-152.272	-4.729
57	.11627	.188	.001	.188	3.075	-174.818	-5.429
58	.11831	.194	.002	.194	2.680	-195.437	-6.069
59	.12035	.200	.004	.200	2.234	-212.277	-6.592
60	.12239	.204	.005	.204	1.747	-224.026	-6.957
61	.12443	.207	.005	.207	1.233	-229.455	-7.126
62	.12647	.209	.006	.209	.713	-228.544	-7.098
63	.12851	.210	.005	.210	.204	-221.892	-6.891
64	.13055	.210	.004	.210	-.264	-210.315	-6.532

DATE: 9 JUN 77 TEST NUMBER: 1039

RSO STUDY, SUBJECT C 2, FUN1033, 751117, NYLON 11 POINT QUADRATIC FIT

HIP MOTION RELATIVE TO THE SLED

FRAME	TIME	DISPLACEMENT X	DISPLACEMENT Z	DISPLACEMENT RESULTANT	VELOCITY RESULTANT	ACCELERATION RESULTANT	ACCELERATION RESULTANT
NO.	(SEC)	(FEET)	(FEET)	(FEET)	(FT/SEC)	(FT/SEC SQ)	(G)
65	.13259	.208	.003	.208	-.693	-194.796	-6.050
66	.13463	.206	.001	.206	-1.072	-176.506	-5.482
67	.13667	.203	.001	.203	-1.413	-156.527	-4.861
68	.13871	.199	.001	.199	-1.702	-135.565	-4.210
69	.14075	.196	.001	.196	-1.963	-114.263	-3.549
70	.14279	.191	.001	.191	-2.180	-92.648	-2.877
71	.14483	.187	.000	.187	-2.354	-71.280	-2.214
72	.14687	.181	.000	.181	-2.481	-50.968	-1.583
73	.14891	.176	-.001	.176	-2.556	-33.244	-1.032
74	.15095	.170	-.002	.170	-2.583	-19.104	-.593
75	.15299	.164	-.003	.164	-2.566	-9.736	-.302
76	.15503	.159	-.004	.159	-2.522	-4.994	-.155
77	.15707	.154	-.005	.154	-2.481	-3.977	-.123
78	.15911	.149	-.005	.149	-2.469	-5.239	-.163
79	.16115	.145	-.005	.145	-2.494	-6.573	-.204
80	.16319	.140	-.005	.140	-2.554	-5.868	-.182
81	.16523	.136	-.005	.136	-2.620	-1.177	-.037
82	.16727	.130	-.005	.130	-2.656	8.594	.267
83	.16931	.123	-.007	.123	-2.678	22.997	.714
84	.17135	.116	-.007	.117	-2.631	40.451	1.256
85	.17339	.111	-.009	.111	-2.521	58.412	1.814
86	.17543	.105	-.009	.106	-2.351	74.700	2.320
87	.17747	.101	-.009	.101	-2.132	87.749	2.725
88	.17951	.097	-.008	.097	-1.896	96.723	3.004
89	.18155	.094	-.008	.094	-1.656	101.275	3.145
90	.18359	.091	-.007	.091	-1.440	102.113	3.171
91	.18563	.088	-.007	.089	-1.233	100.119	3.109
92	.18767	.086	-.007	.086	-1.035	96.053	2.983
93	.18971	.083	-.007	.084	-.846	90.351	2.806
94	.19175	.082	-.007	.082	-.666	83.100	2.581
95	.19379	.081	-.006	.081	-.487	74.552	2.315
96	.19583	.080	-.003	.080	-.317	63.997	1.987
97	.19787	.080	-.001	.080	-.173	51.805	1.609
98	.19990	.080	.002	.080	-.074	38.557	1.197
99	.20194	.080	.004	.080	-.015	25.101	.780
100	.20398	.080	.007	.081	.015	12.409	.385
101	.20602	.081	.009	.081	.000	1.363	.042
102	.20806	.080	.011	.081	-.033	-7.485	-.232
103	.21010	.080	.013	.081	-.078	-14.116	-.438
104	.21214	.079	.016	.081	-.124	-18.967	-.589
105	.21418	.079	.018	.081	-.161	-22.532	-.700
106	.21622	.077	.020	.080	-.201	-25.296	-.786
107	.21826	.076	.023	.079	-.249	-28.218	-.876
108	.22030	.075	.026	.079	-.308	-31.175	-.968
109	.22234	.073	.028	.078	-.375	-33.503	-1.040
110	.22438	.072	.030	.078	-.447	-34.497	-1.071
111	.22642	.070	.032	.077	-.534	-33.507	-1.041
112	.22846	.068	.033	.075	-.633	-30.503	-.947
113	.23050	.065	.035	.074	-.721	-25.663	-.797
114	.23254	.062	.037	.073	-.777	-19.794	-.615

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1039, 751117, NYLON 11 POINT QUADRATIC FIT

HIP MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
115	.23458	.059	.039	.071	-.802	-13.936	-.433
116	.23662	.056	.039	.068	-.804	-8.641	-.268
117	.23866	.053	.040	.067	-.795	-5.193	-.161
118	.24070	.050	.041	.065	-.773	-3.594	-.112
119	.24274	.048	.042	.064	-.761	-3.100	-.096
120	.24478	.046	.043	.063	-.772	-2.445	-.076
121	.24682	.043	.044	.061	-.790	-.745	-.023
122	.24886	.040	.044	.059	-.837	2.621	.081
123	.25090	.037	.045	.058	-.861	7.788	.242
124	.25294	.034	.045	.056	-.851	15.043	.467
125	.25498	.030	.045	.054	-.804	23.415	.727
126	.25702	.026	.044	.051	-.731	31.234	.970
127	.25906	.023	.043	.049	-.640	37.356	1.160
128	.26110	.021	.044	.048	-.537	40.379	1.254
129	.26314	.021	.044	.049	-.418	40.481	1.257
130	.26518	.020	.044	.048	-.311	38.433	1.194
131	.26722	.019	.043	.047	-.233	34.904	1.084
132	.26925	.020	.043	.047	-.180	30.483	.947
133	.27130	.019	.043	.047	-.141	26.031	.808
134	.27334	.020	.042	.046	-.103	22.368	.695
135	.27538	.019	.042	.046	-.061	20.038	.622

MAXIMUM POSITIVE X DISPLACEMENT= .210 AT TIME .12851

MAXIMUM NEGATIVE X DISPLACEMENT= -.001 AT TIME .03672

MAXIMUM POSITIVE Z DISPLACEMENT= .045 AT TIME .25294

MAXIMUM NEGATIVE Z DISPLACEMENT= -.009 AT TIME .17543

MAXIMUM RESULTANT DISPLACEMENT= .210 AT TIME .12851

DATE: 9 JUN 77 TEST NUMBER: 1039

PSD STUDY, SUBJECT C 2, RUN1033, 761117, NYLON 11 POINT QUADRATIC FIT

KNEE MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
15	.03060	.006	.005	.008	-.130	21.088	.655
16	.03264	.005	.004	.007	-.037	28.307	.879
17	.03458	.006	.003	.006	.068	30.862	.958
18	.03672	.006	.002	.006	.151	28.949	.899
19	.03876	.008	.001	.008	.213	24.013	.746
20	.04080	.009	.001	.009	.266	18.240	.566
21	.04284	.009	.001	.009	.291	14.165	.440
22	.04488	.010	.002	.010	.277	12.735	.396
23	.04632	.010	.004	.010	.257	15.376	.478
24	.04896	.010	.004	.011	.254	21.858	.679
25	.05100	.011	.004	.012	.276	32.432	1.007
26	.05304	.010	.004	.011	.351	46.891	1.456
27	.05508	.010	.005	.012	.454	63.581	1.975
28	.05712	.011	.006	.012	.608	79.998	2.484
29	.05916	.013	.007	.014	.789	94.640	2.939
30	.06120	.014	.007	.016	1.027	106.551	3.309
31	.06324	.016	.009	.018	1.299	115.091	3.574
32	.06528	.018	.010	.021	1.576	120.304	3.736
33	.06731	.021	.011	.024	1.838	122.387	3.801
34	.06935	.025	.012	.028	2.094	122.526	3.805
35	.07139	.031	.012	.033	2.343	121.719	3.780
36	.07343	.037	.012	.038	2.583	121.972	3.788
37	.07547	.043	.011	.044	2.806	124.179	3.856
38	.07751	.049	.011	.050	3.033	128.486	3.990
39	.07955	.055	.010	.056	3.276	134.141	4.166
40	.08159	.061	.011	.062	3.549	139.755	4.340
41	.08363	.069	.012	.070	3.864	143.504	4.457
42	.08567	.076	.012	.077	4.192	144.129	4.476
43	.08771	.085	.014	.086	4.533	139.038	4.318
44	.08975	.095	.014	.096	4.870	126.916	3.941
45	.09179	.106	.014	.107	5.168	106.964	3.322
46	.09383	.118	.013	.119	5.400	79.678	2.474
47	.09587	.129	.013	.130	5.583	46.512	1.444
48	.09791	.141	.011	.142	5.659	8.855	.275
49	.09995	.154	.011	.154	5.642	-31.187	-.969
50	.10199	.166	.010	.166	5.521	-71.503	-2.221
51	.10403	.177	.009	.178	5.313	-111.012	-3.448
52	.10607	.189	.008	.189	5.023	-148.279	-4.605
53	.10811	.200	.006	.200	4.660	-181.552	-5.638
54	.11015	.209	.004	.209	4.238	-210.315	-6.532
55	.11219	.217	.002	.217	3.762	-234.050	-7.269
56	.11423	.224	-.000	.224	3.219	-253.012	-7.858
57	.11627	.230	-.003	.230	2.652	-267.279	-8.301
58	.11831	.236	-.005	.236	2.062	-276.587	-8.590
59	.12035	.240	-.007	.240	1.468	-280.366	-8.707
60	.12239	.242	-.008	.242	.877	-278.112	-8.637
61	.12443	.243	-.009	.243	.283	-270.863	-8.412
62	.12647	.243	-.007	.243	-.304	-259.737	-8.066
63	.12851	.241	-.006	.241	-.857	-245.002	-7.609
64	.13055	.238	-.005	.239	-1.350	-227.813	-7.075

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

KNEE MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
65	.13259	.235	-.005	.235	-1.775	-208.858	-6.486
66	.13463	.230	-.005	.231	-2.181	-189.088	-5.872
67	.13667	.225	-.005	.225	-2.545	-169.685	-5.270
68	.13871	.219	-.006	.220	-2.855	-151.542	-4.706
69	.14075	.214	-.007	.214	-3.139	-134.696	-4.183
70	.14279	.207	-.007	.207	-3.387	-117.919	-3.662
71	.14483	.199	-.006	.199	-3.611	-100.238	-3.113
72	.14687	.192	-.003	.192	-3.813	-82.512	-2.562
73	.14891	.184	-.001	.184	-3.985	-64.663	-2.008
74	.15095	.175	.002	.175	-4.114	-45.979	-1.428
75	.15299	.167	.004	.167	-4.178	-26.370	-.819
76	.15503	.157	.006	.157	-4.193	-5.130	-.159
77	.15707	.148	.008	.148	-4.187	17.785	.552
78	.15911	.139	.009	.140	-4.147	42.616	1.323
79	.16115	.131	.011	.131	-4.057	69.576	2.161
80	.16319	.123	.012	.123	-3.916	98.592	3.062
81	.16523	.114	.015	.115	-3.710	130.158	4.042
82	.16727	.106	.018	.107	-3.419	163.402	5.075
83	.16931	.097	.021	.100	-3.052	196.468	6.101
84	.17135	.089	.026	.093	-2.599	226.537	7.035
85	.17339	.082	.031	.087	-2.073	251.263	7.803
86	.17543	.075	.037	.084	-1.474	268.483	8.338
87	.17747	.068	.044	.081	-.840	276.352	8.582
88	.17951	.062	.051	.080	-.184	273.507	8.494
89	.18155	.056	.059	.081	.433	260.241	8.082
90	.18359	.050	.066	.083	1.002	237.996	7.391
91	.18563	.044	.074	.086	1.508	208.605	6.478
92	.18767	.036	.082	.090	1.914	174.618	5.423
93	.18971	.030	.090	.095	2.218	138.336	4.296
94	.19175	.024	.097	.100	2.438	102.502	3.183
95	.19379	.019	.104	.106	2.589	68.795	2.136
96	.19583	.016	.111	.112	2.675	38.684	1.201
97	.19786	.012	.117	.118	2.730	14.015	.435
98	.19990	.010	.123	.123	2.670	-5.054	-.157
99	.20194	.008	.128	.128	2.605	-18.798	-.584
100	.20398	.006	.134	.134	2.518	-27.152	-.843
101	.20602	.005	.139	.139	2.413	-30.480	-.947
102	.20806	.003	.144	.144	2.333	-29.412	-.913
103	.21010	.003	.149	.149	2.262	-25.154	-.781
104	.21214	.001	.153	.153	2.206	-19.233	-.597
105	.21418	-.000	.157	.157	2.181	-13.173	-.409
106	.21622	-.001	.161	.161	2.175	-8.357	-.260
107	.21826	-.003	.165	.165	2.185	-5.840	-.181
108	.22030	-.006	.170	.170	2.201	-5.089	-.158
109	.22234	-.008	.174	.175	2.212	-5.807	-.180
110	.22438	-.010	.180	.180	2.204	-7.454	-.231
111	.22642	-.013	.184	.185	2.173	-9.077	-.282
112	.22846	-.016	.188	.189	2.126	-9.966	-.310
113	.23050	-.018	.192	.193	2.085	-9.559	-.297
114	.23254	-.020	.196	.197	2.055	-7.923	-.246

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1033, 761117, NYLON 11 POINT QUADRATIC FIT

KNEE MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
115	.23458	-.022	.200	.201	2.040	-5.417	-.168
116	.23662	-.024	.203	.204	2.037	-3.055	-.095
117	.23866	-.026	.207	.209	2.049	-1.938	-.060
118	.24070	-.028	.211	.213	2.069	-2.183	-.068
119	.24274	-.030	.216	.218	2.082	-3.835	-.119
120	.24478	-.032	.220	.222	2.085	-6.592	-.205
121	.24682	-.035	.223	.226	2.063	-10.203	-.317
122	.24886	-.038	.227	.230	2.016	-14.485	-.450
123	.25090	-.040	.231	.235	1.980	-18.789	-.584
124	.25294	-.042	.235	.239	1.936	-22.479	-.698
125	.25498	-.045	.239	.243	1.892	-25.844	-.803
126	.25702	-.047	.241	.246	1.840	-28.936	-.899
127	.25906	-.048	.245	.250	1.773	-32.524	-1.010
128	.26110	-.049	.249	.254	1.705	-36.828	-1.144
129	.26314	-.051	.252	.257	1.639	-41.726	-1.296
130	.26518	-.051	.256	.261	1.552	-47.734	-1.482
131	.26722	-.052	.258	.264	1.455	-54.716	-1.699
132	.26926	-.052	.261	.267	1.334	-62.659	-1.946
133	.27130	-.052	.264	.269	1.212	-71.514	-2.221
134	.27334	-.052	.267	.272	1.059	-80.491	-2.500
135	.27538	-.051	.269	.274	.889	-88.709	-2.755

MAXIMUM POSITIVE X DISPLACEMENT= .243 AT TIME .12647

MAXIMUM NEGATIVE X DISPLACEMENT= -.052 AT TIME .26926

MAXIMUM POSITIVE Z DISPLACEMENT= .275 AT TIME .28150

MAXIMUM NEGATIVE Z DISPLACEMENT= -.009 AT TIME .12443

MAXIMUM RESULTANT DISPLACEMENT= .279 AT TIME .28150

DATE: 9 JUN 77 TEST NUMBER: 1039

[illegible] STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

SHOULDER MOTION RELATIVE TO THE SLED

FRAME	TIME	DISPLACEMENT			VELOCITY	ACCELERATION	ACCELERATION
		X	Z	RESULTANT	RESULTANT	RESULTANT	RESULTANT
NO.	(SEC)	(FEET)	(FEET)	(FEET)	(FT/SEC)	(FT/SEC SQ)	(G)
15	.03050	-.002	-.002	.002	.056	-4.115	-.128
16	.03264	-.002	-.003	.003	.044	-9.131	-.284
17	.03468	-.001	-.002	.002	.024	-10.770	-.334
18	.03672	-.001	-.002	.002	-.038	-9.515	-.295
19	.03876	-.000	-.002	.002	-.084	-6.202	-.193
20	.04080	-.000	-.002	.002	-.114	-2.008	-.062
21	.04234	.000	-.002	.002	-.111	2.901	.090
22	.04488	.001	-.001	.001	-.072	8.876	.276
23	.04632	.000	.000	.000	-.034	15.937	.495
24	.04836	.000	-.000	.000	.005	22.730	.706
25	.05100	-.001	-.001	.001	.050	30.126	.936
26	.05304	-.001	-.001	.002	.099	39.148	1.216
27	.05508	-.001	-.001	.002	.169	51.442	1.598
28	.05712	-.002	-.002	.002	.267	67.981	2.111
29	.05916	-.001	-.002	.002	.378	88.829	2.759
30	.06120	.000	-.003	.003	.543	113.012	3.510
31	.06324	.001	-.003	.003	.778	139.404	4.329
32	.06528	.004	-.002	.005	1.099	165.775	5.148
33	.06731	.007	-.003	.007	1.485	190.527	5.917
34	.06935	.010	-.003	.010	1.944	212.168	6.589
35	.07139	.014	-.003	.014	2.443	228.728	7.103
36	.07343	.019	-.003	.020	2.975	239.342	7.433
37	.07547	.026	-.003	.027	3.501	243.666	7.567
38	.07751	.034	-.004	.034	4.024	242.515	7.532
39	.07955	.043	-.004	.043	4.539	236.311	7.339
40	.08159	.053	-.003	.053	5.032	226.357	7.030
41	.08363	.064	-.002	.064	5.497	213.376	6.627
42	.08567	.076	-.001	.076	5.924	198.278	6.158
43	.08771	.089	-.001	.089	6.322	180.363	5.601
44	.08975	.102	-.002	.102	6.677	159.615	4.957
45	.09179	.116	-.003	.116	6.996	135.961	4.222
46	.09383	.131	-.003	.131	7.272	109.871	3.412
47	.09587	.146	-.005	.146	7.504	81.296	2.525
48	.09791	.162	-.006	.162	7.652	49.575	1.540
49	.09995	.178	-.006	.178	7.727	14.353	.446
50	.10199	.195	-.006	.195	7.720	-24.825	-.771
51	.10403	.211	-.006	.211	7.656	-67.656	-2.101
52	.10607	.228	-.005	.228	7.510	-113.935	-3.538
53	.10811	.242	-.005	.243	7.260	-163.036	-5.063
54	.11015	.257	-.005	.257	6.892	-214.259	-6.654
55	.11219	.271	-.004	.271	6.403	-264.813	-8.224
56	.11423	.285	-.004	.285	5.801	-310.396	-9.640
57	.11627	.298	-.004	.298	5.076	-345.747	-10.737
58	.11831	.308	-.004	.308	4.232	-366.893	-11.394
59	.12035	.316	-.003	.316	3.305	-371.123	-11.526
60	.12239	.322	-.002	.322	2.375	-358.020	-11.119
61	.12443	.326	-.002	.326	1.536	-329.300	-10.227
62	.12647	.327	-.002	.327	.836	-288.477	-8.959
63	.12851	.325	-.002	.325	.285	-241.419	-7.497
64	.13055	.323	-.003	.323	-.101	-195.804	-6.081

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT G 2, RUN1239, 761117, NYLON 11 POINT QUADRATIC FIT

SHOULDER MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
65	.13259	.322	-.004	.322	-.354	-157.742	-4.899
66	.13463	.322	-.005	.322	-.516	-130.516	-4.053
67	.13657	.321	-.006	.321	-.634	-113.790	-3.534
68	.13871	.320	-.007	.320	-.772	-105.289	-3.270
69	.14075	.319	-.008	.320	-.993	-101.929	-3.165
70	.14279	.318	-.011	.318	-1.265	-99.498	-3.090
71	.14483	.315	-.013	.315	-1.549	-94.916	-2.948
72	.14687	.311	-.015	.311	-1.798	-86.535	-2.687
73	.14891	.305	-.020	.306	-1.994	-74.510	-2.314
74	.15095	,299	-.025	.300	-2.129	-60.900	-1.891
75	.15299	.294	-.030	.295	-2.191	-49.109	-1.525
76	.15503	.289	-.035	.291	-2.208	-41.307	-1.283
77	.15707	.284	-.039	.287	-2.215	-37.424	-1.162
78	.15911	.280	-.043	.283	-2.249	-35.844	-1.113
79	.16115	.275	-.047	.279	-2.336	-33.930	-1.054
80	.16319	.270	-.050	.275	-2.465	-28.625	-.889
81	.16523	.264	-.053	.270	-2.612	-17.184	-.534
82	.16727	.258	-.054	.264	-2.716	1.184	.037
83	.16931	.251	-.056	.258	-2.754	26.060	.809
84	.17135	.244	-.057	.251	-2.695	54.801	1.702
85	.17339	.238	-.057	.244	-2.521	83.554	2.595
86	.17543	.232	-.055	.238	-2.250	108.599	3.373
87	.17747	.228	-.051	.234	-1.930	126.882	3.940
88	.17951	.226	-.047	.231	-1.574	138.337	4.296
89	.18155	.225	-.042	.228	-1.231	143.881	4.468
90	.18359	.224	-.035	.227	-.923	145.256	4.511
91	.18563	.224	-.028	.226	-.653	144.649	4.492
92	.18767	.224	-.020	.225	-.417	143.961	4.471
93	.18971	.224	-.013	.224	-.159	143.412	4.454
94	.19175	.223	-.004	.223	.132	142.569	4.428
95	.19379	.223	.005	.223	.451	139.702	4.339
96	.19583	.223	.015	.224	.783	132.401	4.112
97	.19736	.224	.025	.225	1.115	118.392	3.677
98	,19990	.227	.035	.229	1.410	97.058	3.014
99	.20194	.229	.045	.234	1.638	70.215	2.181
100	.20398	.232	.054	.238	1.778	40.516	1.258
101	.20602	.234	.064	.242	1.811	10.234	.318
102	.20806	.235	.073	.246	1.732	-18.378	-.571
103	.21010	.236	.082	.250	1.597	-43.083	-1.338
104	.21214	.237	.089	.253	1.444	-62.668	-1.946
105	.21418	.237	.096	.256	1.287	-76.888	-2.388
106	.21622	.236	.103	.258	1.109	-86.867	-2.698
107	.21826	.236	.107	.259	.917	-94.892	-2.947
108	.22030	.237	.111	.262	.721	-102.844	-3.194
109	.22234	.238	.114	.264	.519	-109.915	-3.414
110	.22438	.238	.117	.265	.307	-114.866	-3.567
111	.22642	.236	.121	.265	.063	-117.093	-3.636
112	.22846	.234	.124	.265	-.232	-115.903	-3.599
113	.23050	.231	.127	.264	-.542	-110.564	-3.434
114	.23254	.228	.130	.263	-.796	-100.881	-3.133

DATE: 9 JUN 77 TEST NUMBER: 1039

RSO STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

SHOULDER MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
115	.23458	.224	.134	.261	-.996	-87.184	-2.708
116	.23662	.220	.135	.258	-1.173	-70.481	-2.189
117	.23866	.215	.135	.254	-1.298	-53.292	-1.655
118	.24070	.212	.134	.251	-1.363	-38.769	-1.204
119	.24274	.209	.135	.249	-1.389	-28.271	-.878
120	.24478	.206	.135	.246	-1.387	-20.996	-.652
121	.24682	.202	.134	.242	-1.380	-16.888	-.524
122	.24886	.199	.134	.240	-1.403	-16.993	-.528
123	.25090	.196	.135	.238	-1.462	-20.223	-.628
124	.25294	.193	.134	.235	-1.516	-24.512	-.761
125	.25498	.190	.134	.233	-1.551	-28.718	-.892
126	.25702	.187	.131	.228	-1.604	-31.755	-.986
127	.25906	.184	.128	.224	-1.703	-33.273	-1.033
128	.26110	.181	.126	.221	-1.799	-33.678	-1.046
129	.26314	.179	.124	.218	-1.868	-33.109	-1.028
130	.26518	.177	.122	.215	-1.934	-30.796	-.956
131	.26722	.173	.119	.210	-1.993	-25.918	-.805
132	.26926	.169	.117	.206	-2.054	-19.394	-.602
133	.27130	.165	.115	.201	-2.112	-12.980	-.403
134	.27334	.161	.113	.197	-2.139	-7.497	-.233
135	.27538	.156	.112	.192	-2.132	-2.926	-.091

MAXIMUM POSITIVE X DISPLACEMENT= .327 AT TIME .12647

MAXIMUM NEGATIVE X DISPLACEMENT= -.002 AT TIME .03254

MAXIMUM POSITIVE Z DISPLACEMENT= .135 AT TIME .23662

MAXIMUM NEGATIVE Z DISPLACEMENT= -.067 AT TIME .17135

MAXIMUM RESULTANT DISPLACEMENT= .327 AT TIME .12647

DATE: 9 JUN 77 TEST NUMBER: 1039

ESD STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

ELBOW MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
15	.03060	.002	.004	.005	-.093	4.011	.125
16	.03264	.003	.003	.004	-.061	10.385	.323
17	.03468	.003	.003	.005	-.002	14.465	.449
18	.03672	.003	.003	.004	.064	16.049	.498
19	.03876	.003	.003	.004	.112	15.073	.468
20	.04080	.002	.004	.005	.144	12.466	.387
21	.04284	.002	.005	.005	.161	9.756	.303
22	.04488	.003	.005	.006	.164	8.390	.261
23	.04692	.003	.006	.007	.160	10.232	.318
24	.04896	.003	.006	.007	.149	16.397	.509
25	.05100	.003	.006	.007	.152	26.971	.838
26	.05304	.004	.006	.007	.179	41.785	1.298
27	.05508	.004	.006	.007	.256	60.593	1.882
28	.05712	.005	.005	.007	.393	82.651	2.567
29	.05916	.006	.005	.008	.587	106.703	3.314
30	.06120	.007	.005	.009	.831	131.489	4.084
31	.06324	.009	.005	.010	1.127	155.530	4.830
32	.06528	.012	.005	.013	1.483	177.671	5.518
33	.06731	.016	.004	.016	1.890	197.469	6.133
34	.06935	.020	.003	.020	2.329	214.387	6.658
35	.07139	.025	.002	.025	2.808	227.762	7.073
36	.07343	.031	.002	.031	3.304	237.077	7.363
37	.07547	.036	.002	.038	3.816	242.085	7.518
38	.07751	.047	.001	.047	4.346	243.494	7.562
39	.07955	.056	.001	.056	4.871	242.286	7.524
40	.08159	.067	.001	.067	5.374	239.071	7.425
41	.08363	.078	.001	.078	5.857	234.928	7.296
42	.08567	.091	.000	.091	6.313	230.971	7.173
43	.08771	.105	.000	.105	6.762	228.427	7.094
44	.08975	.119	-.000	.119	7.212	228.107	7.084
45	.09179	.134	-.001	.134	7.659	229.497	7.127
46	.09383	.150	-.001	.150	8.108	231.425	7.187
47	.09587	.166	-.001	.166	8.582	232.602	7.224
48	.09791	.184	-.002	.184	9.087	231.449	7.188
49	.09995	.204	-.002	.204	9.605	226.655	7.039
50	.10199	.223	-.001	.223	10.103	216.990	6.739
51	.10403	.244	-.001	.244	10.570	201.379	6.254
52	.10607	.267	.000	.267	10.996	179.698	5.581
53	.10811	.291	.002	.291	11.372	153.424	4.765
54	.11015	.315	.003	.315	11.682	124.822	3.876
55	.11219	.339	.005	.339	11.907	96.496	2.997
56	.11423	.364	.008	.364	12.043	70.666	2.195
57	.11627	.389	.011	.389	12.108	49.486	1.537
58	.11831	.414	.014	.415	12.133	34.376	1.068
59	.12035	.439	.017	.440	12.134	26.356	.819
60	.12239	.463	.022	.464	12.134	24.547	.762
61	.12443	.487	.027	.488	12.133	26.053	.809
62	.12647	.512	.032	.513	12.212	27.528	.855
63	.12851	.536	.039	.538	12.301	25.968	.806
64	.13055	.560	.047	.562	12.430	18.596	.578

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

ELBOW MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	Z (FEET)	RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
65	.13259	.584	.056	.587	12.548	3.622	.112
66	.13463	.610	.066	.613	12.600	-19.692	-.612
67	.13667	.636	.077	.640	12.574	-50.292	-1.562
68	.13871	.661	.088	.667	12.466	-85.636	-2.660
69	.14075	.686	.101	.694	12.246	-123.140	-3.824
70	.14279	.709	.116	.719	11.927	-159.528	-4.954
71	.14433	.731	.131	.743	11.512	-193.236	-6.001
72	.14637	.751	.148	.766	11.036	-224.273	-6.965
73	.14831	.770	.164	.788	10.529	-253.476	-7.872
74	.15095	.788	.182	.808	9.989	-281.772	-8.751
75	.15239	.804	.200	.829	9.423	-310.435	-9.641
76	.15503	.819	.217	.848	8.830	-339.601	-10.547
77	.15707	.833	.234	.865	8.108	-368.507	-11.444
78	.15911	.845	.252	.882	7.323	-394.888	-12.264
79	.16115	.856	.268	.897	6.443	-416.008	-12.920
80	.16319	.864	.284	.910	5.485	-429.308	-13.333
81	.16523	.870	.298	.920	4.494	-432.606	-13.435
82	.16727	.875	.311	.929	3.517	-425.520	-13.215
83	.16931	.877	.321	.934	2.602	-408.826	-12.696
84	.17135	.877	.330	.937	1.759	-385.009	-11.957
85	.17339	.875	.340	.939	1.005	-357.499	-11.102
86	.17543	.872	.347	.939	.336	-329.216	-10.224
87	.17747	.869	.354	.939	-.267	-302.836	-9.405
88	.17951	.866	.361	.938	-.819	-278.902	-8.662
89	.18155	.862	.366	.936	-1.343	-256.870	-7.977
90	.18359	.857	.370	.934	-1.855	-235.624	-7.318
91	.18563	.851	.373	.929	-2.330	-213.666	-6.636
92	.18767	.844	.375	.924	-2.789	-189.684	-5.891
93	.18971	.836	.374	.916	-3.183	-163.739	-5.085
94	.19175	.828	.375	.909	-3.510	-136.728	-4.246
95	.19379	.819	.375	.901	-3.757	-110.218	-3.423
96	.19583	.810	.375	.893	-3.923	-86.163	-2.676
97	.19786	.801	.376	.884	-4.016	-65.617	-2.038
98	.19930	.792	.376	.876	-4.073	-49.752	-1.545
99	.20134	.782	.375	.867	-4.124	-38.136	-1.184
100	.20398	.773	.374	.859	-4.180	-29.757	-.924
101	.20602	.765	.373	.851	-4.243	-23.191	-.720
102	.20806	.756	.371	.842	-4.307	-16.243	-.504
103	.21010	.747	.369	.833	-4.363	-6.753	-.210
104	.21214	.738	.367	.825	-4.395	6.060	.188
105	.21418	.728	.366	.815	-4.390	22.345	.694
106	.21622	.719	.364	.806	-4.351	41.291	1.282
107	.21826	.708	.363	.796	-4.254	61.546	1.911
108	.22030	.699	.362	.787	-4.094	81.494	2.531
109	.22234	.689	.361	.778	-3.891	99.874	3.102
110	.22438	.682	.361	.771	-3.638	115.708	3.593
111	.22642	.673	.361	.764	-3.355	128.206	3.982
112	.22846	.666	.351	.757	-3.056	136.388	4.236
113	.23050	.658	.363	.751	-2.755	140.616	4.367
114	.23254	.650	.365	.746	-2.448	141.088	4.382

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

ELBOW MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
115	.23458	.644	.367	.741	-2.141	137.829	4.280
116	.23662	.639	.368	.737	-1.846	131.894	4.096
117	.23866	.634	.370	.734	-1.578	124.014	3.851
118	.24070	.629	.372	.731	-1.317	114.974	3.571
119	.24274	.626	.373	.729	-1.090	105.419	3.274
120	.24478	.624	.375	.728	-.899	95.998	2.981
121	.24682	.620	.376	.725	-.725	87.133	2.706
122	.24886	.618	.378	.724	-.569	78.204	2.429
123	.25090	.615	.381	.724	-.424	68.750	2.135
124	.25294	.613	.383	.723	-.282	59.007	1.833
125	.25498	.610	.386	.722	-.149	48.545	1.508
126	.25702	.609	.388	.722	-.032	37.617	1.168
127	.25906	.607	.391	.722	.032	26.904	.836
128	.26110	.606	.394	.723	.062	17.203	.534
129	.26314	.605	.397	.724	.065	9.113	.283
130	.26518	.605	.399	.724	.036	3.098	.096
131	.26722	.604	.399	.724	.012	-.857	-.027
132	.26926	.603	.400	.724	-.005	-3.271	-.102
133	.27130	.602	.401	.723	-.003	-5.593	-.174
134	.27334	.601	.401	.722	.008	-9.365	-.291
135	.27538	.599	.403	.722	.017	-16.062	-.499

MAXIMUM POSITIVE X DISPLACEMENT= .877 AT TIME .16931

MAXIMUM NEGATIVE X DISPLACEMENT= .002 AT TIME .02244

MAXIMUM POSITIVE Z DISPLACEMENT= .411 AT TIME .28558

MAXIMUM NEGATIVE Z DISPLACEMENT= -.002 AT TIME .09791

MAXIMUM RESULTANT DISPLACEMENT= .939 AT TIME .17747

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1033, 761117, NYLON 11 POINT QUADRATIC FIT

HEAD PT. 1 MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
15	.03060	-.005	.001	.005	.027	-13.161	-.409
16	.03264	-.008	-.001	.008	-.040	-17.596	-.546
17	.03468	-.008	-.002	.008	-.110	-16.123	-.501
18	.03672	-.006	-.002	.007	-.194	-8.553	-.266
19	.03876	-.004	-.003	.005	-.246	2.474	.077
20	.04080	-.002	-.003	.004	-.259	13.525	.420
21	.04284	-.001	-.003	.003	-.203	22.749	.706
22	.04488	-.001	-.002	.002	-.060	28.476	.884
23	.04692	-.001	-.002	.002	.094	28.365	.881
24	.04896	-.001	-.003	.003	.205	21.059	.654
25	.05100	-.003	-.002	.004	.253	9.690	.301
26	.05304	-.006	-.001	.006	.275	-1.951	-.061
27	.05508	-.007	-.001	.007	.248	-6.884	-.214
28	.05712	-.007	-.001	.008	.128	-.508	-.016
29	.05916	-.007	-.001	.007	-.047	19.894	.618
30	.06120	-.006	-.001	.006	-.138	53.184	1.652
31	.06324	-.007	-.001	.007	-.112	96.447	2.995
32	.06528	-.006	-.001	.006	.151	148.191	4.602
33	.06731	-.003	-.002	.003	.558	203.321	6.314
34	.06935	-.001	-.001	.001	1.126	253.032	7.858
35	.07139	.003	-.003	.004	1.778	289.413	8.988
36	.07343	.008	-.004	.009	2.481	310.727	9.650
37	.07547	.016	-.005	.017	3.282	315.880	9.810
38	.07751	.024	-.006	.025	4.067	309.415	9.609
39	.07955	.035	-.006	.035	4.732	293.680	9.120
40	.08159	.045	-.007	.045	5.265	272.927	8.476
41	.08363	.056	-.006	.056	5.759	249.993	7.764
42	.08567	.069	-.006	.070	6.183	227.216	7.056
43	.08771	.082	-.006	.082	6.605	209.293	6.500
44	.08975	.095	-.007	.095	6.992	197.013	6.118
45	.09179	.110	-.009	.111	7.372	188.244	5.846
46	.09333	.126	-.010	.127	7.741	180.634	5.610
47	.09537	.142	-.012	.143	8.096	172.674	5.363
48	.09791	.159	-.014	.160	8.476	161.165	5.005
49	.09995	.176	-.015	.177	8.826	143.539	4.458
50	.10199	.194	-.015	.195	9.137	116.711	3.625
51	.10403	.214	-.016	.214	9.431	78.612	2.441
52	.10607	.234	-.018	.235	9.655	28.897	.897
53	.10811	.254	-.021	.255	9.766	-31.563	-.980
54	.11015	.275	-.023	.276	9.703	-99.233	-3.082
55	.11219	.296	-.022	.297	9.445	-169.726	-5.271
56	.11423	.317	-.024	.318	8.974	-236.021	-7.330
57	.11627	.336	-.027	.337	8.330	-289.670	-8.996
58	.11831	.353	-.030	.355	7.540	-325.095	-10.096
59	.12035	.368	-.032	.369	6.648	-338.264	-10.505
60	.12239	.380	-.034	.381	5.736	-329.459	-10.232
61	.12443	.389	-.040	.391	4.933	-301.676	-9.369
62	.12647	.397	-.044	.400	4.307	-261.063	-8.108
63	.12851	.402	-.051	.406	3.832	-214.897	-6.674
64	.13055	.407	-.056	.411	3.532	-171.199	-5.317

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT G 2, SUN1039, 751117, NYLON 11 POINT QUADRATIC FIT

[illegible] 1 MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
65	.13239	.412	-.061	.416	3.348	-137.142	-4.259
66	.13463	.418	-.069	.424	3.238	-115.890	-3.599
67	.13657	.425	-.077	.432	3.139	-105.565	-3.278
68	.13871	.430	-.085	.439	2.992	-101.818	-3.162
69	.14075	.436	-.092	.446	2.762	-100.212	-3.112
70	.14279	.441	-.100	.452	2.444	-95.678	-2.971
71	.14433	.444	-.109	.457	2.123	-85.413	-2.653
72	.14637	.445	-.116	.460	1.873	-67.850	-2.107
73	.14831	.445	-.126	.462	1.717	-44.863	-1.393
74	.15035	.444	-.133	.464	1.674	-20.569	-.639
75	.15239	.444	-.139	.465	1.733	-.339	-.011
76	.15503	.446	-.147	.469	1.852	10.937	.340
77	.15707	.449	-.153	.474	2.012	12.121	.376
78	.15911	.451	-.160	.479	2.130	5.193	.161
79	.16115	.456	-.166	.485	2.162	-6.219	-.193
80	.16319	.459	-.173	.490	2.089	-17.425	-.541
81	.16523	.461	-.178	.495	1.936	-24.442	-.759
82	.16727	.465	-.182	.499	1.766	-24.628	-.765
83	.16931	.465	-.187	.501	1.630	-16.580	-.515
84	.17135	.467	-.188	.503	1.567	-2.108	-.065
85	.17339	.469	-.188	.505	1.539	14.175	.440
86	.17543	.472	-.187	.508	1.700	27.123	.842
87	.17747	.476	-.185	.511	1.858	33.459	1.039
88	.17951	.481	-.184	.515	2.037	31.478	.978
89	.18155	.488	-.182	.521	2.188	21.921	.681
90	.18359	.494	-.182	.526	2.243	7.701	.239
91	.18563	.503	-.179	.531	2.197	-7.790	-.242
92	.18767	.507	-.177	.537	2.106	-21.176	-.658
93	.18971	.512	-.174	.541	1.970	-29.561	-.918
94	.19175	.518	-.169	.545	1.834	-32.146	-.998
95	.19379	.522	-.163	.547	1.741	-30.064	-.934
96	.19583	.526	-.157	.549	1.681	-26.988	-.838
97	.19786	.531	-.153	.553	1.670	-26.362	-.819
98	.19990	.536	-.149	.556	1.699	-30.101	-.935
99	.20194	.541	-.146	.560	1.713	-39.769	-1.235
100	.20398	.546	-.142	.564	1.676	-54.443	-1.691
101	.20602	.551	-.136	.568	1.552	-72.108	-2.239
102	.20806	.557	-.134	.572	1.360	-89.571	-2.782
103	.21010	.561	-.129	.576	1.105	-103.348	-3.210
104	.21214	.565	-.123	.578	.802	-111.077	-3.450
105	.21418	.566	-.117	.578	.507	-112.624	-3.498
106	.21622	.567	-.112	.578	.219	-109.219	-3.392
107	.21826	.568	-.108	.579	-.004	-102.560	-3.185
108	.22030	.568	-.104	.578	-.162	-94.267	-2.928
109	.22234	.567	-.100	.576	-.292	-87.212	-2.708
110	.22438	.568	-.097	.576	-.429	-82.845	-2.573
111	.22642	.567	-.093	.575	-.591	-81.008	-2.516
112	.22846	.568	-.091	.575	-.750	-81.627	-2.535
113	.23050	.567	-.088	.574	-.907	-82.862	-2.573
114	.23254	.565	-.084	.572	-1.110	-83.046	-2.579

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

HEAD PT. 1 MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
115	.23438	.562	-.080	.568	-1.310	-82.157	-2.551
116	.23662	.559	-.079	.565	-1.492	-80.630	-2.504
117	.23866	.557	-.076	.562	-1.657	-78.566	-2.440
118	.24070	.553	-.075	.558	-1.792	-75.429	-2.343
119	.24274	.549	-.073	.553	-1.912	-71.008	-2.205
120	.24478	.546	-.072	.550	-2.058	-66.055	-2.051
121	.24632	.542	-.071	.546	-2.218	-60.449	-1.877
122	.24836	.538	-.069	.543	-2.357	-54.625	-1.696
123	.25090	.533	-.066	.537	-2.472	-48.694	-1.512
124	.25294	.528	-.064	.531	-2.571	-43.193	-1.341
125	.25498	.521	-.061	.525	-2.635	-38.992	-1.211
126	.25702	.516	-.060	.519	-2.671	-37.277	-1.158
127	.25906	.511	-.057	.514	-2.715	-37.666	-1.170
128	.26110	.505	-.056	.508	-2.757	-38.884	-1.208
129	.26314	.500	-.053	.503	-2.835	-39.371	-1.223
130	.26518	.496	-.052	.499	-2.957	-38.066	-1.182
131	.26722	.491	-.052	.493	-3.102	-32.865	-1.021
132	.26926	.484	-.050	.486	-3.214	-23.197	-.720
133	.27130	.476	-.049	.479	-3.283	-11.089	-.344
134	.27334	.469	-.048	.471	-3.298	1.538	.048
135	.27538	.460	-.044	.463	-3.265	11.955	.371

MAXIMUM POSITIVE X DISPLACEMENT= .568 AT TIME .21826

MAXIMUM NEGATIVE X DISPLACEMENT= -.008 AT TIME .03264

MAXIMUM POSITIVE Z DISPLACEMENT= .002 AT TIME .02244

MAXIMUM NEGATIVE Z DISPLACEMENT= -.188 AT TIME .17339

MAXIMUM RESULTANT DISPLACEMENT= .579 AT TIME .21826

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1433, 751117, NYLON 11 POINT QUADRATIC FIT

HEAD PT. 2 MOTION RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
15	.03050	-.032	.015	.035	.042	-92.875	-2.884
16	.03254	-.030	.014	.033	-.130	-61.569	-1.912
17	.03458	-.029	.014	.032	-.165	-29.260	-.909
18	.03672	-.029	.013	.031	-.082	-1.757	-.055
19	.03876	-.029	.013	.031	.061	17.246	.536
20	.04080	-.029	.013	.031	.167	25.571	.794
21	.04234	-.030	.013	.032	.284	23.688	.736
22	.04438	-.031	.014	.034	.359	14.279	.443
23	.04632	-.032	.015	.036	.376	.446	.014
24	.04836	-.033	.015	.036	.341	-14.158	-.440
25	.05100	-.034	.015	.037	.267	-28.211	-.876
26	.05304	-.034	.015	.037	.169	-42.291	-1.313
27	.05508	-.035	.015	.038	.063	-56.170	-1.744
28	.05712	-.034	.015	.037	-.055	-69.863	-2.170
29	.05916	-.034	.015	.037	-.167	-83.954	-2.607
30	.06120	-.033	.015	.036	-.331	-93.935	-2.917
31	.06324	-.033	.015	.036	-.538	-93.181	-2.894
32	.06528	-.033	.014	.036	-.810	-75.189	-2.335
33	.06731	-.032	.013	.034	-1.110	-35.839	-1.113
34	.06935	-.030	.012	.032	-1.442	25.972	.807
35	.07139	-.027	.011	.029	-1.579	108.862	3.381
36	.07343	-.022	.010	.025	-1.393	206.484	6.413
37	.07547	-.017	.009	.019	-.834	309.896	9.624
38	.07751	-.011	.007	.013	.052	407.000	12.640
39	.07955	-.003	.007	.007	1.198	485.496	15.078
40	.08159	.007	.007	.010	2.529	531.603	16.509
41	.08363	.019	.007	.020	3.926	542.655	16.853
42	.08557	.033	.006	.034	5.286	525.035	16.305
43	.08771	.048	.006	.049	6.494	487.705	15.146
44	.08975	.064	.006	.065	7.480	440.468	13.679
45	.09179	.081	.005	.081	8.143	391.865	12.170
46	.09383	.098	.003	.098	8.651	348.878	10.835
47	.09587	.116	-.000	.116	9.187	315.574	9.800
48	.09791	.134	-.004	.134	9.748	292.683	9.090
49	.09995	.154	-.007	.154	10.357	276.734	8.594
50	.10199	.175	-.010	.175	10.981	260.219	8.081
51	.10403	.197	-.013	.198	11.592	232.658	7.225
52	.10607	.224	-.016	.225	12.163	188.147	5.843
53	.10811	.249	-.019	.250	12.646	127.981	3.975
54	.11015	.277	-.020	.278	12.980	55.129	1.712
55	.11219	.304	-.020	.305	13.069	-23.597	-.733
56	.11423	.332	-.024	.333	12.895	-99.165	-3.080
57	.11627	.359	-.027	.360	12.475	-161.757	-5.024
58	.11831	.387	-.032	.388	11.894	-201.833	-6.268
59	.12035	.412	-.038	.414	11.193	-211.545	-6.570
60	.12239	.432	-.046	.435	10.488	-188.656	-5.859
61	.12443	.451	-.056	.454	9.907	-138.104	-4.289
62	.12647	.467	-.067	.472	9.541	-67.621	-2.100
63	.12851	.480	-.082	.487	9.456	11.201	.348
64	.13055	.494	-.097	.504	9.698	84.819	2.634

DATE: 9 JUN 77 TEST NUMBER: 1039

RSD STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

HEAD PT. 2 RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	DISPLACEMENT Z (FEET)	DISPLACEMENT RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
65	.13259	.509	-.114	.521	10.171	140.643	4.368
66	.13463	.526	-.134	.543	10.744	169.821	5.274
67	.13667	.545	-.154	.567	11.381	168.549	5.234
68	.13871	.568	-.171	.593	11.956	138.347	4.296
69	.14075	.587	-.202	.621	12.317	88.326	2.743
70	.14279	.603	-.232	.646	12.444	30.041	.933
71	.14483	.619	-.263	.672	12.344	-27.118	-.842
72	.14687	.635	-.293	.699	12.046	-76.164	-2.365
73	.14891	.648	-.324	.724	11.615	-112.669	-3.499
74	.15095	.658	-.353	.747	11.242	-137.034	-4.256
75	.15299	.668	-.381	.769	10.938	-154.554	-4.800
76	.15503	.678	-.406	.790	10.670	-171.809	-5.336
77	.15707	.688	-.427	.810	10.446	-194.255	-6.033
78	.15911	.697	-.447	.828	10.184	-226.650	-7.039
79	.16115	.703	-.481	.852	9.799	-270.946	-8.414
80	.16319	.710	-.508	.873	9.243	-320.570	-9.956
81	.16523	.718	-.534	.895	8.488	-367.530	-11.414
82	.16727	.726	-.558	.915	7.583	-404.045	-12.548
83	.16931	.727	-.579	.930	6.541	-421.920	-13.103
84	.17135	.727	-.596	.940	5.424	-418.328	-12.992
85	.17339	.726	-.610	.948	4.394	-394.625	-12.255
86	.17543	.726	-.619	.954	3.508	-355.213	-11.031
87	.17747	.726	-.625	.958	2.814	-306.870	-9.530
88	.17951	.727	-.630	.962	2.348	-255.345	-7.930
89	.18155	.732	-.632	.967	2.005	-206.857	-6.424
90	.18359	.736	-.632	.970	1.734	-166.884	-5.183
91	.18563	.744	-.630	.975	1.494	-137.219	-4.261
92	.18767	.749	-.628	.978	1.251	-116.947	-3.632
93	.18971	.755	-.625	.980	1.033	-103.636	-3.219
94	.19175	.761	-.620	.982	.836	-94.685	-2.941
95	.19379	.766	-.615	.983	.653	-89.784	-2.788
96	.19583	.772	-.608	.982	.472	-89.380	-2.776
97	.19786	.778	-.600	.983	.329	-94.405	-2.932
98	.19990	.785	-.594	.985	.214	-104.572	-3.248
99	.20134	.792	-.587	.986	.058	-117.941	-3.663
100	.20398	.799	-.577	.985	-.171	-132.966	-4.129
101	.20602	.806	-.567	.985	-.482	-148.605	-4.615
102	.20806	.811	-.559	.985	-.881	-162.853	-5.058
103	.21010	.816	-.550	.984	-1.295	-172.092	-5.344
104	.21214	.819	-.539	.981	-1.686	-173.720	-5.395
105	.21418	.821	-.528	.976	-2.067	-167.858	-5.213
106	.21622	.821	-.515	.970	-2.456	-155.586	-4.832
107	.21826	.822	-.503	.963	-2.739	-139.386	-4.329
108	.22030	.822	-.493	.959	-3.056	-122.659	-3.809
109	.22234	.822	-.481	.953	-3.254	-106.777	-3.316
110	.22438	.822	-.467	.945	-3.425	-91.705	-2.848
111	.22642	.820	-.454	.937	-3.559	-79.478	-2.468
112	.22846	.817	-.443	.930	-3.686	-71.910	-2.233
113	.23050	.816	-.432	.923	-3.825	-68.343	-2.122
114	.23254	.812	-.419	.914	-3.955	-66.521	-2.066

DATE: 9 JUN 77 TEST NUMBER: 1039

PSD STUDY, SUBJECT C 2, RUN1039, 761117, NYLON 11 POINT QUADRATIC FIT

HEAD PT. 2 ON RELATIVE TO THE SLED

FRAME NO.	TIME (SEC)	DISPLACEMENT X (FEET)	Z (FEET)	RESULTANT (FEET)	VELOCITY RESULTANT (FT/SEC)	ACCELERATION RESULTANT (FT/SEC SQ)	ACCELERATION RESULTANT (G)
115	.23458	.809	-.406	.906	-4.035	-65.296	-2.028
116	.23662	.806	-.396	.898	-4.198	-62.992	-1.956
117	.23866	.801	-.387	.890	-4.367	-58.279	-1.810
118	.24070	.795	-.379	.881	-4.517	-49.322	-1.532
119	.24274	.786	-.370	.871	-4.630	-35.453	-1.101
120	.24478	.781	-.363	.862	-4.734	-16.505	-.513
121	.24632	.772	-.357	.851	-4.777	6.644	.206
122	.24886	.763	-.351	.840	-4.779	30.165	.937
123	.25090	.755	-.346	.831	-4.679	49.983	1.552
124	.25294	.747	-.340	.820	-4.490	63.385	1.968
125	.25498	.739	-.334	.811	-4.240	68.152	2.117
126	.25702	.732	-.331	.803	-3.989	63.344	1.967
127	.25906	.723	-.328	.794	-3.787	50.262	1.561
128	.26110	.718	-.324	.787	-3.669	30.516	.948
129	.26314	.713	-.320	.782	-3.636	8.952	.278
130	.26518	.710	-.316	.777	-3.712	-10.324	-.321
131	.26722	.702	-.312	.769	-3.833	-22.944	-.713
132	.26926	.695	-.310	.761	-3.973	-28.485	-.885
133	.27130	.686	-.307	.752	-4.109	-28.448	-.883
134	.27334	.678	-.302	.742	-4.176	-25.637	-.796
135	.27538	.668	-.298	.732	-4.199	-22.713	-.705

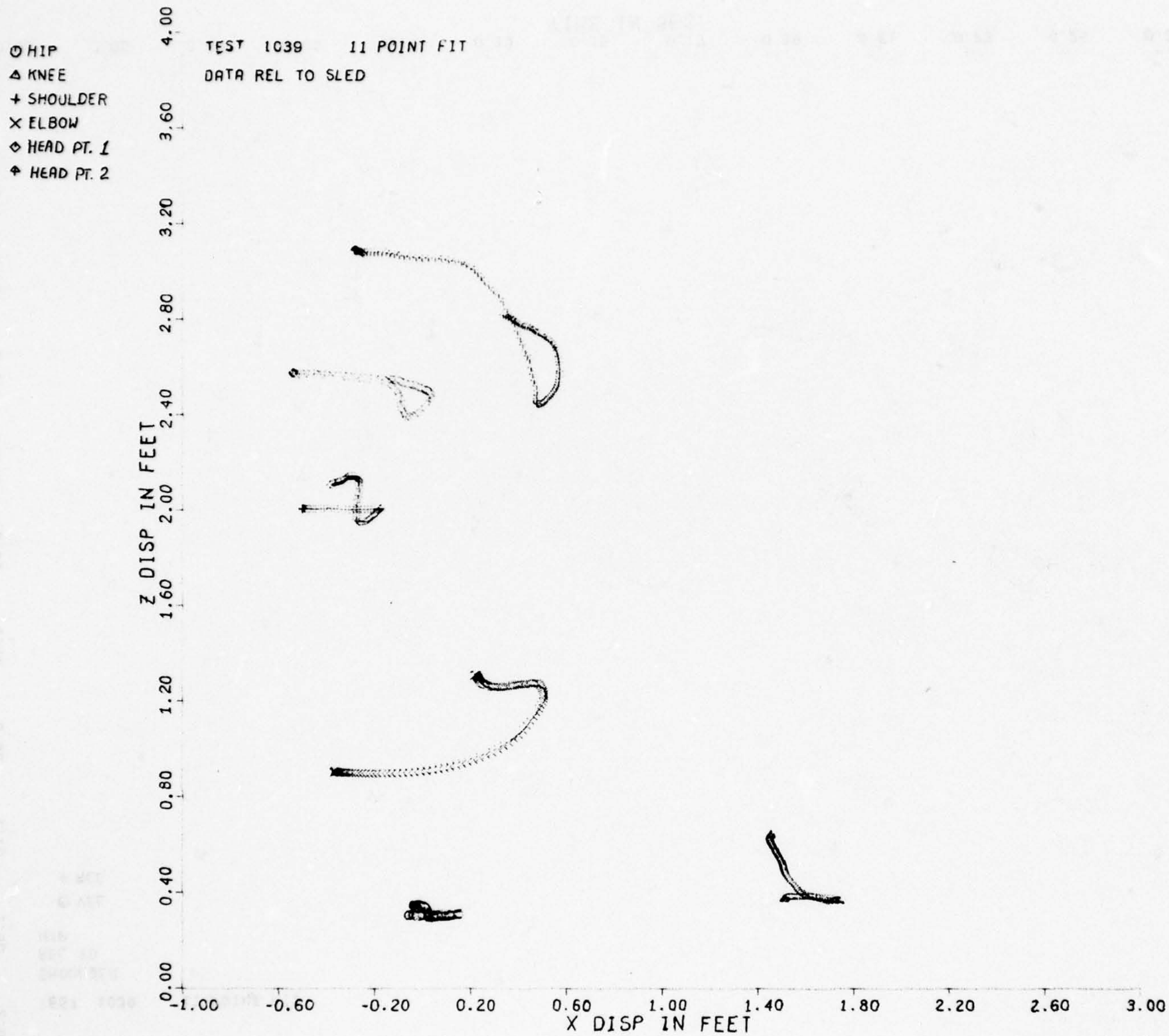
MAXIMUM POSITIVE X DISPLACEMENT= .822 AT TIME .22030

MAXIMUM NEGATIVE X DISPLACEMENT= -.035 AT TIME .05508

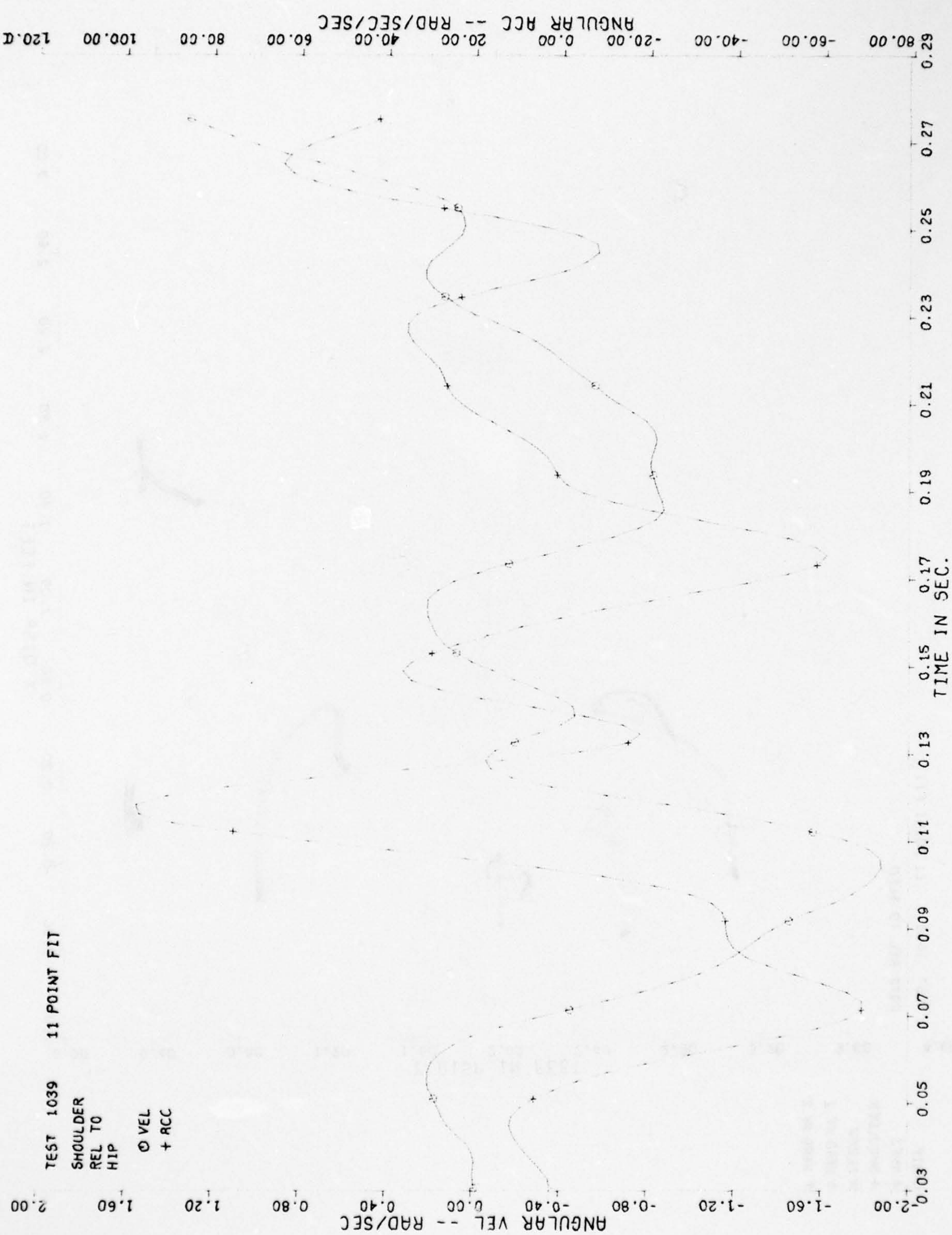
MAXIMUM POSITIVE Z DISPLACEMENT= .017 AT TIME .02652

MAXIMUM NEGATIVE Z DISPLACEMENT= -.632 AT TIME .18155

MAXIMUM RESULTANT DISPLACEMENT= .986 AT TIME .20194



TEST 1039 11 POINT FIT
DATA REL TO SLED
HIP
KNEE
SHOULDER
ELBOW
HEAD PT. 1
HEAD PT. 2
Z DISP IN FEET
X DISP IN FEET
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
-1.00
-0.60
-0.20
0.20
0.60
1.00
1.40
1.80
2.20
2.60
3.00


TEST 1039
11 POINT FIT
SHOULDER
REL TO
HIP
⊙ VEL
+ ACC
TIME IN SEC.
ANGULAR VEL -- RAD/SEC
ANGULAR ACC -- RAD/SEC/SEC
0.03
0.05
0.07
0.09
0.11
0.13
0.15
0.17
0.19
0.21
0.23
0.25
0.27
0.29
-2.00
-1.60
-1.20
-0.80
-0.40
0.00
0.40
0.80
1.20
1.60
2.00
-80.00
-60.00
-40.00
-20.00
0.00
20.00
40.00
60.00
80.00
100.00
120.0

AD-A062 006 DAYTON UNIV OHIO RESEARCH INST F/G 5/5
PHOTOMETRIC METHODS FOR THE ANALYSIS OF HUMAN KINEMATIC RESPONS--ETC(U)
OCT 78 P A GRAF, H T MOHLMAN, R C REBOULET F33615-73-C-4157
UNCLASSIFIED UDRI-TR-76-88 AMRL-TR-78-94 NL

3 OF 4
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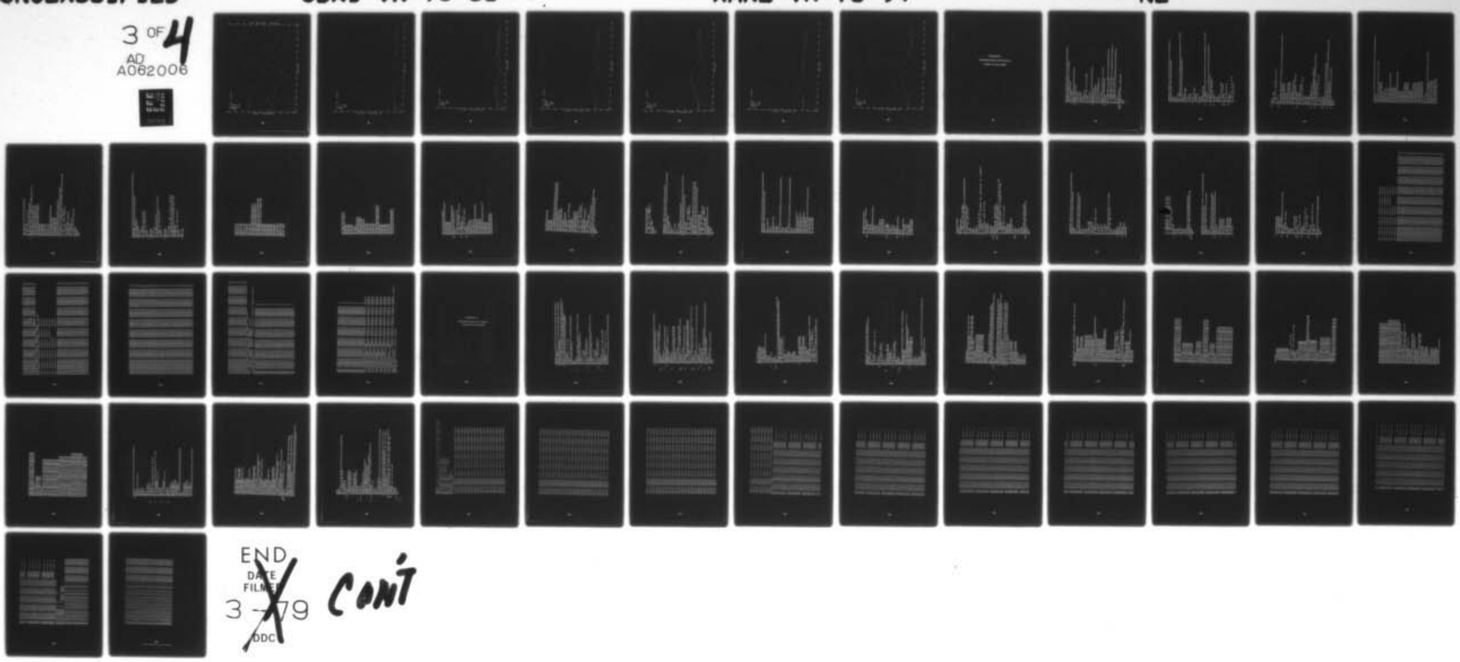
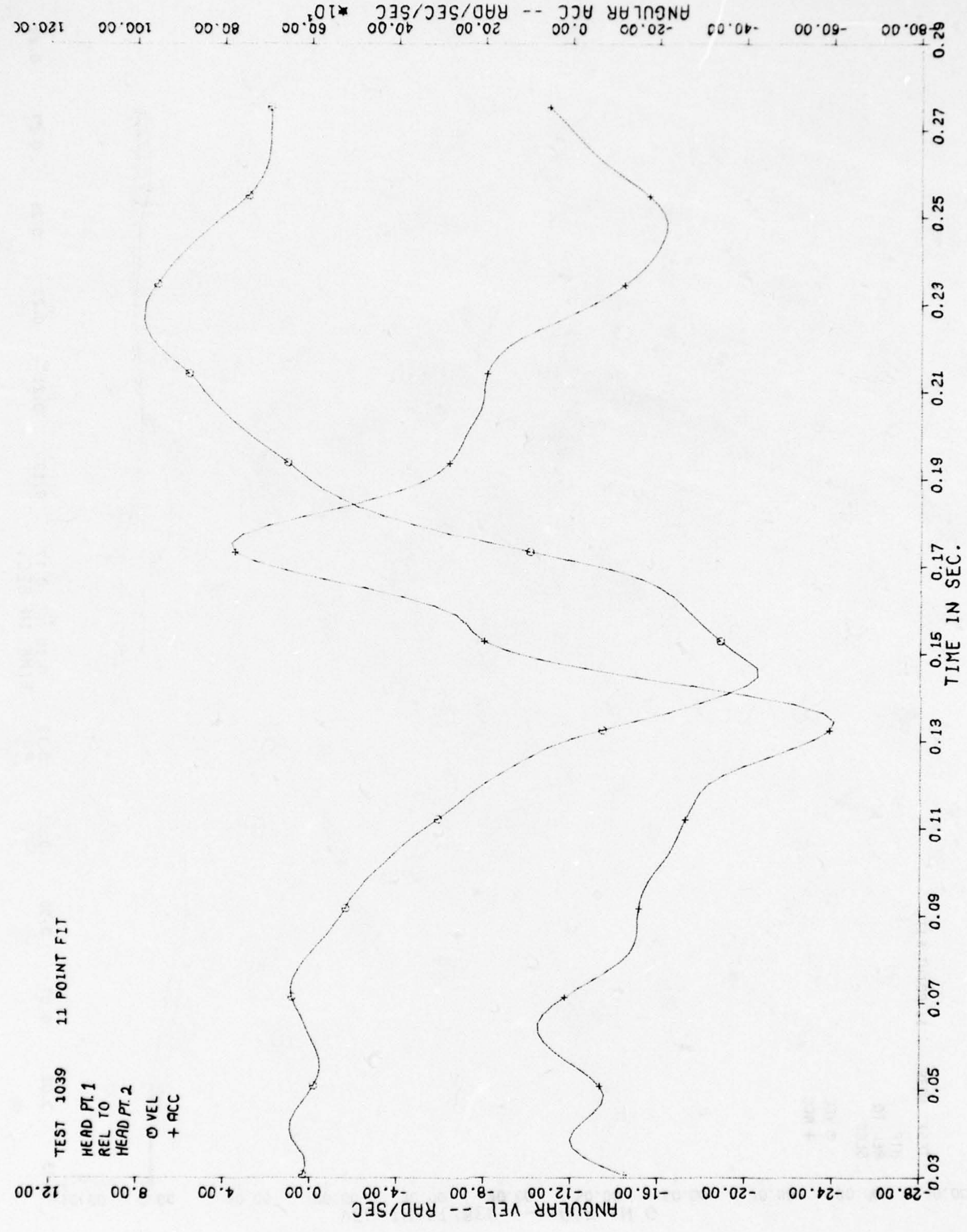
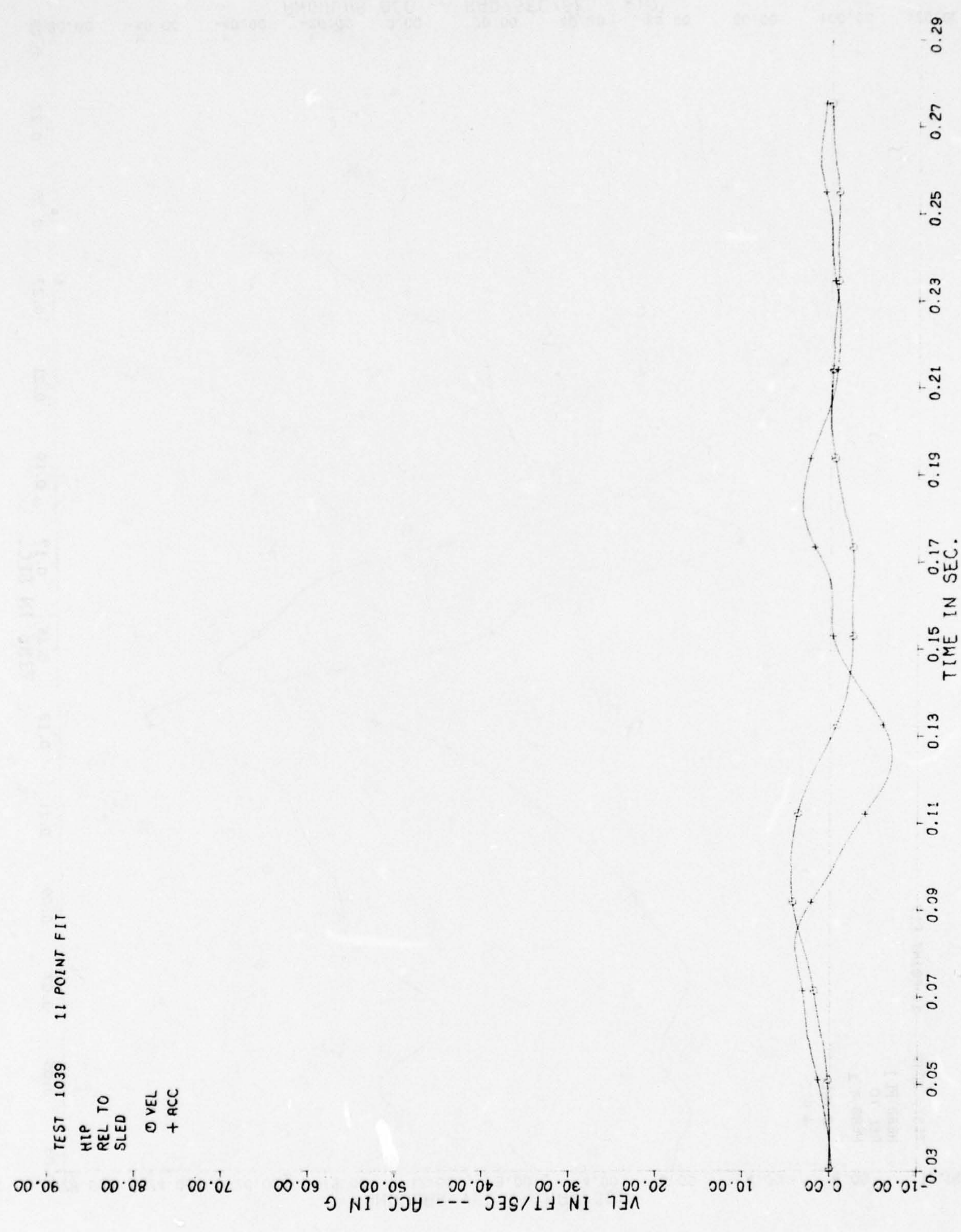


END
DATE
FILMED
3-79
DDC

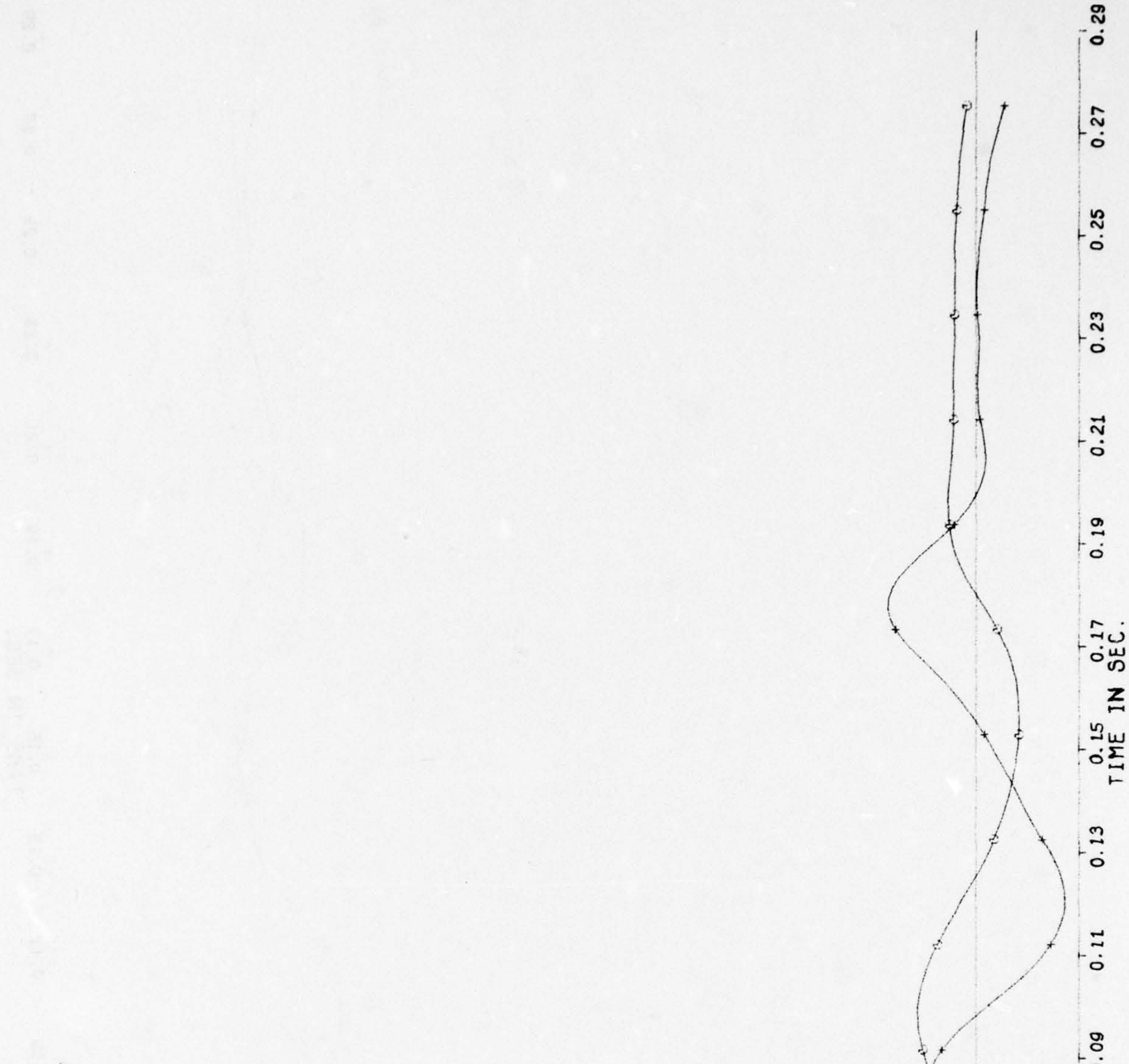
CON'T

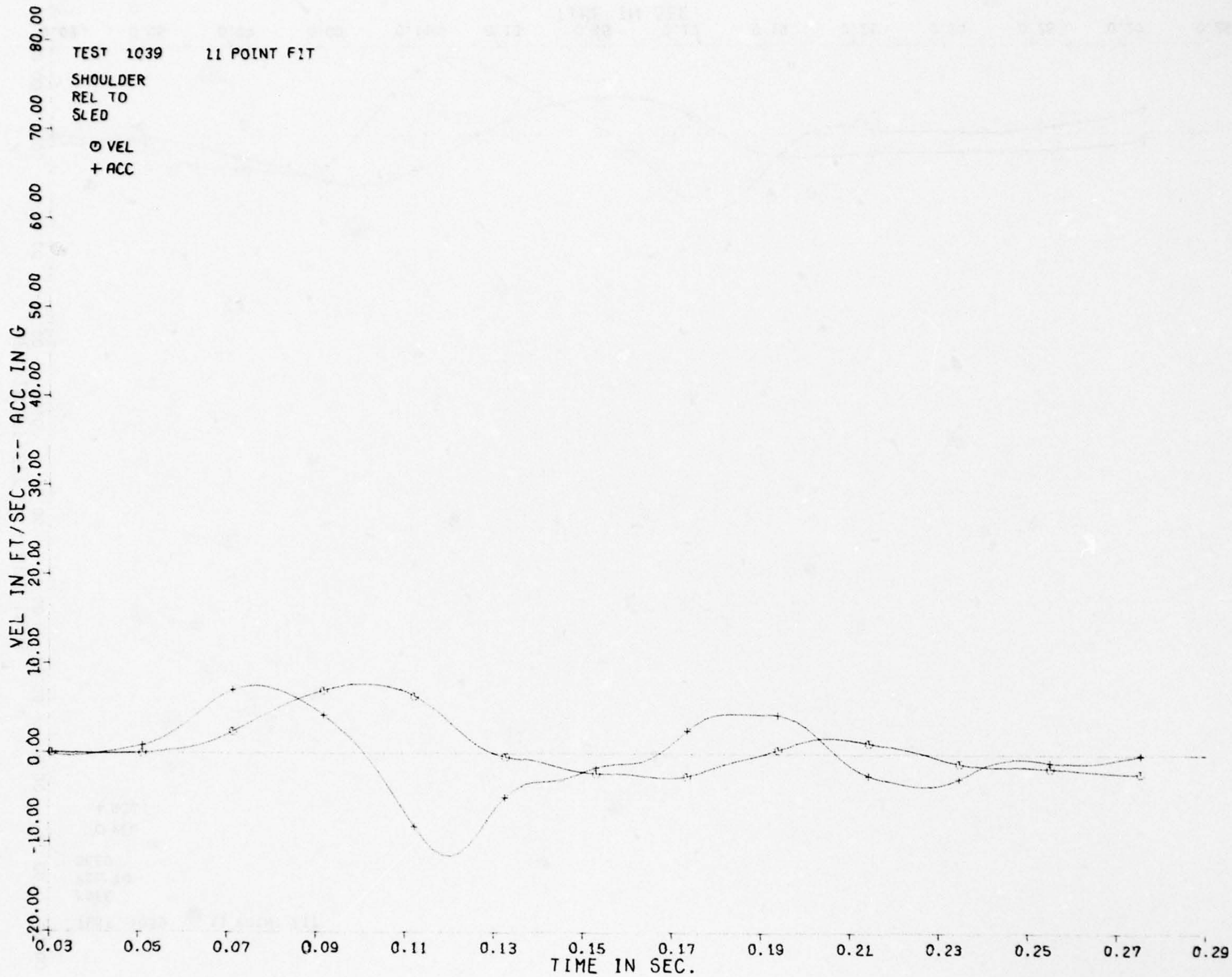


TEST 1039 11 POINT FIT
HEAD PT. 1
REL TO
HEAD PT. 2
⊙ VEL
+ ACC
ANGULAR VEL -- RAD/SEC
ANGULAR ACC -- RAD/SEC/SEC *10¹
TIME IN SEC.

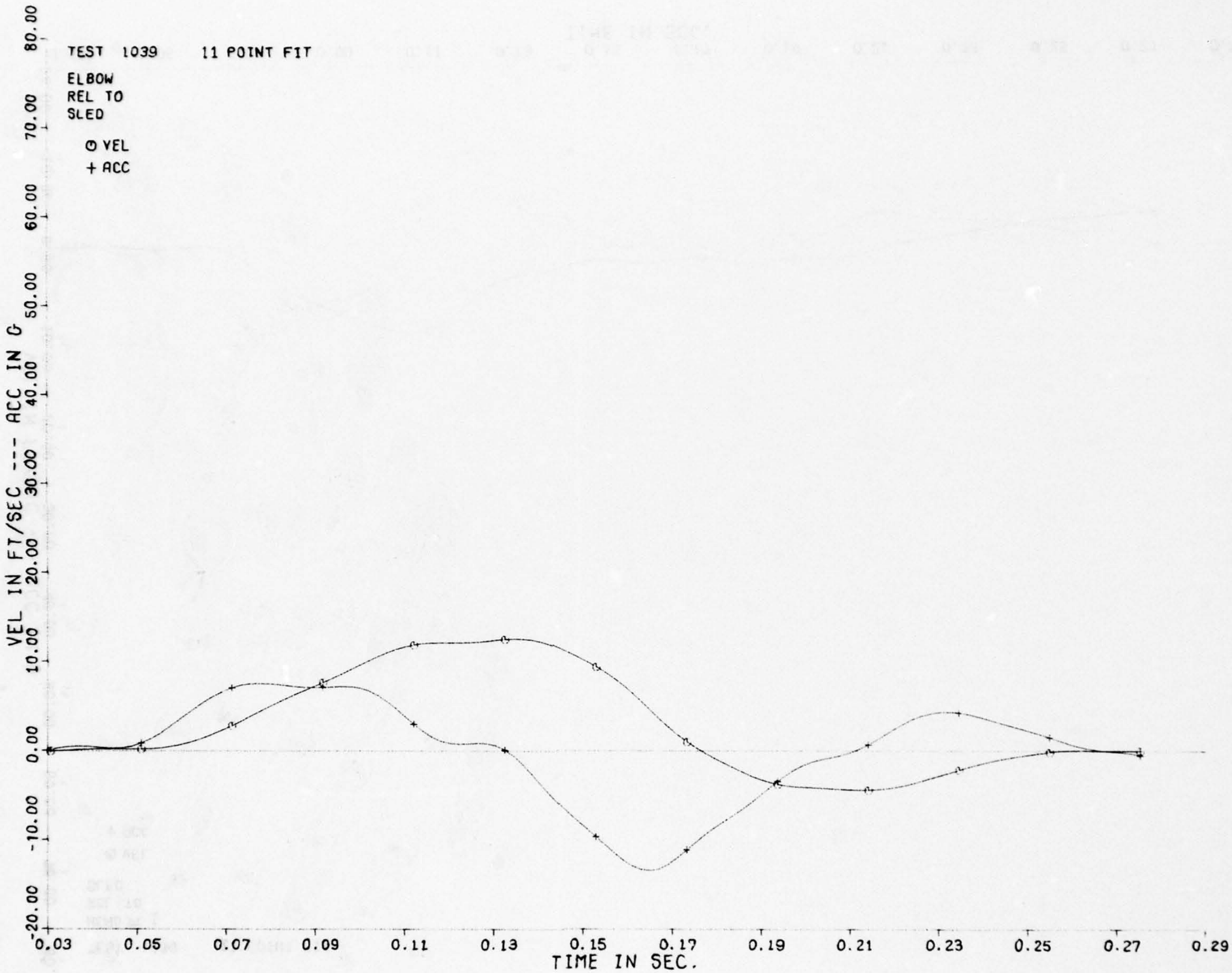


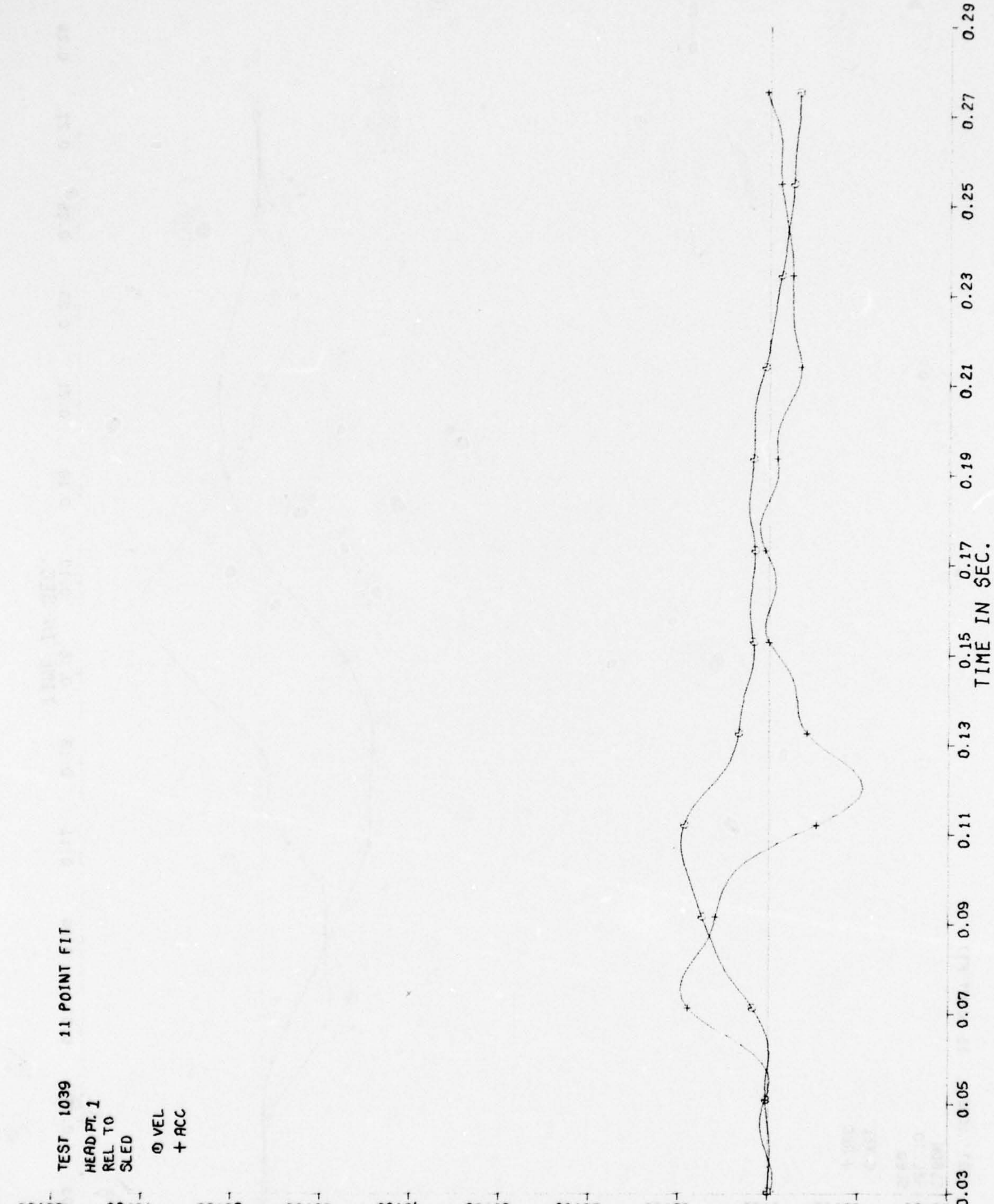
TEST 1039 11 POINT FIT
HIP
REL TO
SLED
O VEL
+ ACC
VEL IN FT/SEC --- ACC IN G
-10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
0.03
0.05
0.07
0.09
0.11
0.13
0.15
0.17
0.19
0.21
0.23
0.25
0.27
0.29
TIME IN SEC.

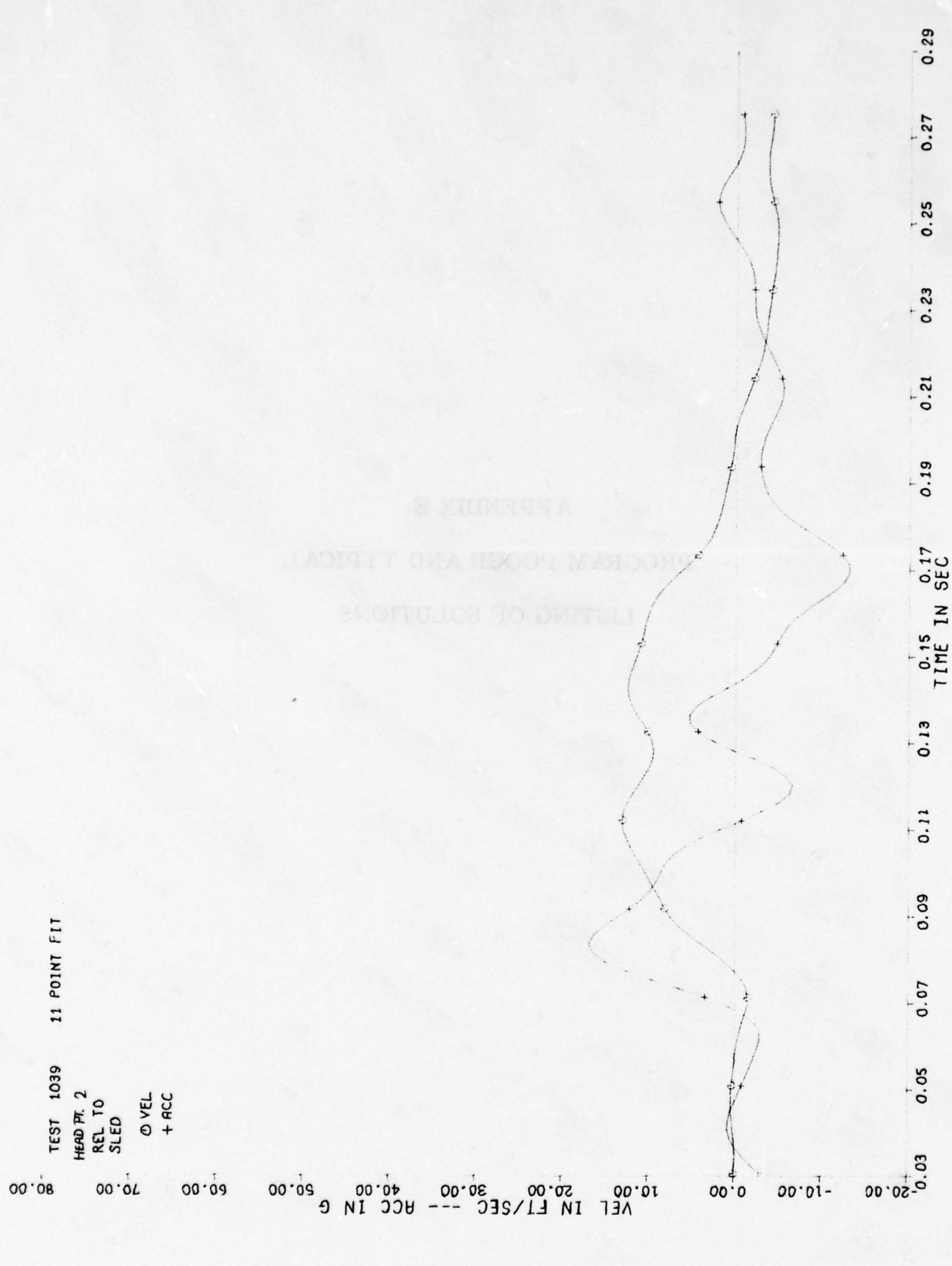

TEST 1039 11 POINT FIT
KNEE
REL TO
SLED
⊙ VEL
+ ACC
VEL IN FT/SEC --- ACC IN G
TIME IN SEC.
-10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
0.03
0.05
0.07
0.09
0.11
0.13
0.15
0.17
0.19
0.21
0.23
0.25
0.27
0.29



TEST 1039
11 POINT FIT
SHOULDER
REL TO
SLED
⊙ VEL
+ ACC
VEL IN FT/SEC --- ACC IN G
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
0.03
0.05
0.07
0.09
0.11
0.13
0.15
0.17
0.19
0.21
0.23
0.25
0.27
0.29
TIME IN SEC.


TEST 1039 11 POINT FIT
ELBOW
REL TO
SLED
VEL
+ ACC
VEL IN FT/SEC --- ACC IN G
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
0.03
0.05
0.07
0.09
0.11
0.13
0.15
0.17
0.19
0.21
0.23
0.25
0.27
0.29
TIME IN SEC.


TEST 1039 11 POINT FIT
HEAD PT. 1
REL TO
SLED
⊙ VEL
+ ACC
VEL IN FT/SEC --- ACC IN G
TIME IN SEC.
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
0.03
0.05
0.07
0.09
0.11
0.13
0.15
0.17
0.19
0.21
0.23
0.25
0.27
0.29


TEST 1039
11 POINT FIT
HEAD PT. 2
REL TO
SLED
O VEL
+ ACC
VEL IN FT/SEC --- ACC IN G
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
0.03
0.05
0.07
0.09
0.11
0.13
0.15
0.17
0.19
0.21
0.23
0.25
0.27
0.29
TIME IN SEC

APPENDIX E

PROGRAM POOCH AND TYPICAL LISTING OF SOLUTIONS

```
      PROGRAM POOCH(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      DIMENSION X(20),Y(20),Z(20),P(20),Q(20)
      DTR=3.14159265/180.0
      RTD=1.0/DTR
    1 READ(5,2)XX,YY,ZZ,FF,FP,FQ,XSR,N
    2 FORMAT(7F10.0,I5)
      FF=FF/12.0
      FP=FP/12.0
      FQ=FQ/12.0
      YY=-YY
      ICHK=EOF(5)
      IF (ICHK .NE. 0) GO TO 2000
      NSTOP=0
      DO 3 I=1,N
      READ(5,4) P(I),Q(I),X(I),Y(I),Z(I)
    4 FORMAT(5F10.0)
      P(I)=-P(I)/12000.0
      Q(I)=Q(I)/12000.0
      Q(I)=Q(I)*(1.0-XSR*P(I))
      Y(I)=-Y(I)
      WRITE(6,6)P(I),Q(I),X(I),Y(I),Z(I)
    6 FORMAT(6H POOCJ,5E13.6/)
    3 CONTINUE
      CALL FIND(XX,YY,ZZ,FF,ERR,X,Y,Z,P,Q,N,NSTOP,FP,FQ)
      IF (NSTOP .EQ. 1) GO TO 1
      CALL SERCH(XX,YY,ZZ,FF,X,Y,Z,P,Q,N,NSTOP,TH,PH,GAM,K,L)
      IF (NSTOP .EQ. 1) GO TO 1
      CALL DANG(XX,YY,ZZ,FF,TH,PH,GAM,X,Y,Z,P,Q,N,DNG,K,L)
      GO TO 1
 2000 WRITE(6,2001)
 2001 FORMAT(18H NORMAL COMPLETION    )
      STOP
      END
```

```
      SUBROUTINE DANG(XX,YY,ZZ,FF,TH,PH,GAM,X,Y,Z,P,Q,N,DNG,K,L)
      DIMENSION X(20),Y(20),Z(20),P(20),Q(20)
      NRE=0
      KTR=1
      NTR=0
      DNG=0.03
      CALL WRANG(XX,YY,ZZ,FF,TH,PH,GAM,X,Y,Z,P,Q,N,ERR,NRE,K,L,THI,PHI)
      WRITE(6,11)XX,YY,ZZ,FF,TH,PH,GAM,ERR,NTR
      XMO=1.0
    1 TS=TH+XMO*DNG
      PS=PH
      GAS=GAM
      GO TO 20
    2 TS=TH
      PS=PH+XMO*DNG
      GAS=GAM
      GO TO 20
    3 TS=TH
      PS=PH
      GAS=GAM+XMO*DNG
   20 CALL WRANG(XX,YY,ZZ,FF,TS,PS,GAS,X,Y,Z,P,Q,N,ERS,NRE,K,L,THI,PHI)
      NTR=NTR+1
      IF (NTR .LT. 51) WRITE(6,100)TS,PS,GAS,ERS,DNG,XMO,KTR
  100 FORMAT(5H DANG,6E13.6,I5)
      IF (ERR-ERS) 22,22,21
   21 ERR=ERS
      TH=TS
      PH=PS
      GAM=GAS
      GO TO (1,2,3) ,KTR
   22 IF (XMO) 24,23,23
   23 XMO=-1.0
      GO TO (1,2,3),KTR
   24 XMO=1.0
      KTR=KTR+1
      IF (KTR .GT. 3) GO TO 25
      GO TO (1,2,3),KTR
```

```
25 KTR=1
   DNG=0.1*DNG
   IF (DNG .LT. 0.0000029) GO TO 26
   GO TO 1
26 NRE=1
   CALL WRANG(XX,YY,ZZ,FF,TH,PH,GAM,X,Y,Z,P,Q,N,ERR,NRE,K,L,THI,PHI)
   RFA=COS(TH)*COS(PH)
   RFB=SIN(TH)*COS(PH)
   RFC=SIN(PH)
   RIA=COS(THI)*COS(PHI)
   RIB=SIN(THI)*COS(PHI)
   RIC=SIN(PHI)
   RFM=SQRT(RFA**2+RFB**2)
   IF (RFM-0.00000001) 30,30,31
31 SIA=-RFB/RFM
   SIB=RFA/RFM
   HAG=SIA*RIA+SIB*RIB
   IF (HAG .GT. 0.0) GO TO 34
   SIA=-SIA
   SIB=-SIB
   SIC=-SIC
   HAG=-HAG
34 CALL AKOS(HAG,TILT)
   IF (ABS(TILT)-0.00000001) 30,30,32
32 TELL=RFA*(SIB*RIC-RIB*SIC)-RFB*(SIA*RIC-SIC*RIA)+
  1RFC*(SIA*RIB-SIB*RIA)
   IF (TELL .LT. 0.0) TILT=-TILT
   GO TO 33
30 TILT=0.0
33 CONTINUE
   WRITE(6,11)XX,YY,ZZ,FF,TH,PH,GAM,ERR,NTR
11 FORMAT(19H X,Y,Z,F,AZ,EL,TILT,7E13.6/12H ERROR@ITER.,E13.6,I5)
   WRITE(6,10)THI,PHI,TILT
10 FORMAT(18H DAMG,THI,PHI,TILT,3E13.6)
   RETURN
   END
```

```
      SUBROUTINE WRANG(XX,YY,ZZ,FF,TH,PH,GAM,X,Y,Z,P,Q,N,ERR,NRE,K,L,
     1THI,PHI)
      DIMENSION X(20),Y(20),Z(20),P(20),Q(20)
      FN1=COS(TH)*COS(PH)
      FN2=SIN(TH)*COS(PH)
      FN3=SIN(PH)
      PIPA=X(K)-X(L)
      PIPB=Y(K)-Y(L)
      PIPC=Z(K)-Z(L)
      A=FN1*PIPA+FN2*PIPB+FN3*PIPC
      PIA=PIPA-A*FN1
      PIB=PIPB-A*FN2
      PIC=PIPC-A*FN3
      PID=SQRT(PIA**2+PIB**2+PIC**2)
      PIA=PIA/PID
      PIB=PIB/PID
      PIC=PIC/PID
      PJA=FN2*PIC-FN3*PIB
      PJB=FN3*PIA-FN1*PIC
      PJC=FN1*PIB-FN2*PIA
      COG=COS(GAM)
      SIG=SIN(GAM)
      TIA=COG*PIA+SIG*PJA
      TIB=COG*PIB+SIG*PJB
      TIC=COG*PIC+SIG*PJC
      TJA=-SIG*PIA+COG*PJA
      TJB=-SIG*PIB+COG*PJB
      TJC=-SIG*PIC+COG*PJC
      ERR=0.0
      DO 1 I=1,N
      W=FF/((X(I)-XX)*FN1+(Y(I)-YY)*FN2+(Z(I)-ZZ)*FN3)
      RA=W*(X(I)-XX)-FF*FN1
      RB=W*(Y(I)-YY)-FF*FN2
      RC=W*(Z(I)-ZZ)-FF*FN3
      PA=RA*TIA+RB*TIB+RC*TIC
      QA=RA*TJA+RB*TJB+RC*TJC
```

```
      ERA=SQRT((P(I)-PA)**2+(Q(I)-QA)**2)
      ERR=ERR+ERA
      IF (NRE .EQ. 0) GO TO 1
      WRITE(6,2) I,P(I),Q(I),PA,QA,ERA
    2 FORMAT(26H READ PT. PIERCE PT.,ERROR,I5,5E13.6)
      PHA=FF*FN1+P(I)*TIA+Q(I)*TJA
      PHB=FF*FN2+P(I)*TIB+Q(I)*TJB
      PHC=FF*FN3+P(I)*TIC+Q(I)*TJC
      DPH=SQRT(PHA**2+PHB**2+PHC**2)
      PHA=PHA/DPH
      PHB=PHB/DPH
      PHC=PHC/DPH
      SHA=X(I)-XX
      SHB=Y(I)-YY
      SHC=Z(I)-ZZ
      ACOF=PHA*SHA+PHB*SHB+PHC*SHC
      DISA=ACOF*PHA-SHA
      DISB=ACOF*PHB-SHB
      DISC=ACOF*PHC-SHC
      DIS=SQRT(DISA**2+DISB**2+DISC**2)
      WRITE(6,3) I,X(I),Y(I),Z(I),DISA,DISB,DISC,DIS
    3 FORMAT(37H ITH OBJECT POINT AND DISTANCE VECTOR/I5,7E13.6)
      IF (TIC .GT. 1.0) TIC=1.0
      IF (TIC .LT. -1.0) TIC=-1.0
      PHI=ASIN(TIC)
      TDM=SQRT(TIA**2+TIB**2)
      ARG=TIA/TDM
      CALL AKOS(ARG,THI)
      IF (TIB .LT. 0.0) THI=-THI
    1 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SERCH(XX,YY,ZZ,FF,X,Y,Z,P,Q,N,NSTOP,TH,PH,GAM,K,L)
      DIMENSION X(20),Y(20),Z(20),P(20),Q(20)
      DTR=0.01745329252
      RTD=1.0/DTR
      STO=0.0
      DO 1 I=1,N
      STA=SQRT(P(I)**2+Q(I)**2)
      IF (STA .LE. STO) GO TO 1
      STO=STA
      K=I
    1 CONTINUE
      STO=0.0
      DO 2 I=1,N
      IF (K .EQ. I) GO TO 2
      STA=SQRT((P(K)-P(I))**2+(Q(K)-Q(I))**2)
      IF (STA .LE. STO) GO TO 2
      STO=STA
      L=I
    2 CONTINUE
      STO=0.0
      DO 3 I=1,N
      IF ((I .EQ. K) .OR. (I .EQ. L)) GO TO 3
      STA=SQRT((P(I)-P(K))**2+(Q(I)-Q(K))**2)
      STB=SQRT((P(I)-P(L))**2+(Q(I)-Q(L))**2)
      STA=STA+STB
      IF (STA .LE. STO) GO TO 3
      STO=STA
      M=I
    3 CONTINUE
```

```
FAA=X(K)-XX
FAB=Y(K)-YY
FAC=Z(K)-ZZ
FBA=X(L)-XX
FBB=Y(L)-YY
FBC=Z(L)-ZZ
FCA=X(M)-XX
FCB=Y(M)-YY
FCC=Z(M)-ZZ
DAM=SQRT(FAA**2+FAB**2+FAC**2)
DBM=SQRT(FBA**2+FBB**2+FBC**2)
DCM=SQRT(FCA**2+FCB**2+FCC**2)
DAM=DAM/SQRT(FF**2+P(K)**2+Q(K)**2)
DBM=DBM/SQRT(FF**2+P(L)**2+Q(L)**2)
DCM=DCM/SQRT(FF**2+P(M)**2+Q(M)**2)
FAA=FAA/DAM
FAB=FAB/DAM
FAC=FAC/DAM
FBA=FBA/DBM
FBB=FBB/DBM
FBC=FBC/DBM
FCA=FCA/DCM
FCB=FCB/DCM
FCC=FCC/DCM
WA=P(K)-P(M)
WB=Q(K)-Q(M)
UA=P(L)-P(M)
UB=Q(L)-Q(M)
```

```
WAB=SQRT(WA**2+WB**2)
UAB=SQRT(UA**2+UB**2)
WA=WA/WAB
WB=WB/WAB
UA=UA/UAB
UB=UB/UAB
CA=-P(M)
CB=-Q(M)
FLAM=WA*UB-WB*UA
COFA=CA*UB-CB*UA
COFB=WA*CB-WB*CA
COFA=COFA/FLAM
COFB=COFB/FLAM
WA=FAA-FCA
WB=FAB-FCB
WC=FAC-FCC
UA=FBA-FCA
UB=FBB-FCB
UC=FBC-FCC
WAB=SQRT(WA**2+WB**2+WC**2)
UAB=SQRT(UA**2+UB**2+UC**2)
WA=WA/WAB
WB=WB/WAB
WC=WC/WAB
UA=UA/UAB
UB=UB/UAB
UC=UC/UAB
FN1=FCA+COFA*WA+COFB*UA
FN2=FCB+COFA*WB+COFB*JB
```

```
      FN3=FCC+COFA*WC+COFB*UC
      DCKN=SQRT(FN1**2+FN2**2+FN3**2)
      FN1=FN1/DCKN
      FN2=FN2/DCKN
      FN3=FN3/DCKN
      WRITE(6,12)FN1,FN2,FN3,DCKN
   12 FORMAT(6H SERCH,4E13.6)
      TH=0.0
      DIM=SQRT(FN1**2+FN2**2)
      IF (DIM -0.00000001) 13,13,14
   14 ARG=FN1/DIM
      CALL AKOS(ARG,TH)
      IF (FN2 .LT. 0.0) TH=-TH
   13 CONTINUE
      PH=ASIN(FN3)
      PIPA=X(K)-X(L)
      PIPB=Y(K)-Y(L)
      PIPC=Z(K)-Z(L)
      A=FN1*PIPA+FN2*PIPB+FN3*PIPC
      PIA=PIPA-A*FN1
      PIB=PIPB-A*FN2
      PIC=PIPC-A*FN3
      PID=SQRT(PIA**2+PIB**2+PIC**2)
      PIA=PIA/PID
      PIB=PIB/PID
      PIC=PIC/PID
      PJA=FN2*PIC-FN3*PIB
      PJB=FN3*PIA-FN1*PIC
```

```
      PJC=FN1*PIB-FN2*PIA
      FFA=FF*FN1
      FFB=FF*FN2
      FFC=FF*FN3
      ELA=(FAA-FFA)*PIA+(FAB-FFB)*PIB+(FAC-FFC)*PIC
      ELB=(FAA-FFA)*PJA+(FAB-FFB)*PJB+(FAC-FFC)*PJC
      DEL=P(K)**2+Q(K)**2
      DSA=P(K)*ELB-Q(K)*ELA
      DCA=P(K)*ELA+Q(K)*ELB
      ARG=DCA/DEL
      CALL AKOS(ARG,GAM)
      ARG=DSA/DEL
      IF (ARG .LT. 0.0) GAM=-GAM
      COG=COS(GAM)
      SIG=SIN(GAM)
      GIA=COG*PIA+SIG*PJA
      GIB=COG*PIB+SIG*PJB
      GIC=COG*PIC+SIG*PJC
      IF (GIC .GT. 1.0) GIC=1.0
      IF (GIC .LT. -1.0) GIC=-1.0
      PHI=ASIN(GIC)
      GDM=SQRT(GIA**2+GIB**2)
      ARG=GIA/GDM
      CALL AKOS(ARG,THI)
      IF (GIB .LT. 0.0) THI=-THI
      WRITE(6,20) XX,YY,ZZ,FF,TH,PH,GAM,THI,PHI
   20 FORMAT(6H SERCH,5E13.6/6X,4E13.6)
      RETURN
      END
```

```
      SUBROUTINE AKOS(ARG,ANG)
      IF (ARG .GT. 1.0) ARG=1.0
      IF (ARG .LT. -1.0) ARG=-1.0
      ANG=ACOS(ARG)
      RETURN
      END

      SUBROUTINE ANGLE(XX,YY,ZZ,FF,ERR,X,Y,Z,P,Q,N)
      DIMENSION X(20),Y(20),Z(20),P(20),Q(20),G(20,20),H(20,20)
      DTR=0.01745329252
      RTD=1.0/DTR
      ERR=0.0
      M=N-1
      DO 1 I=1,M
      K=I+1
      DO 1 J=K,N
      ROM=FF**2+P(I)*P(J)+Q(I)*Q(J)
     0RAD=SQRT(FF**4+(P(I)**2+Q(I)**2+P(J)**2+Q(J)**2)*FF**2
     1+(P(I)**2+Q(I)**2)*(P(J)**2+Q(J)**2))
      ARG=ROM/RAD
      IF (ARG .GT. 1.0) ARG=1.0
      IF (ARG .LT. -1.0) ARG=-1.0
      G(I,J)=ACOS(ARG)
      RAD1=SQRT((X(I)-XX)**2+(Y(I)-YY)**2+(Z(I)-ZZ)**2)
      RAD2=SQRT((X(J)-XX)**2+(Y(J)-YY)**2+(Z(J)-ZZ)**2)
      DOM=(X(I)-XX)*(X(J)-XX)+(Y(I)-YY)*(Y(J)-YY)+
     1(Z(I)-ZZ)*(Z(J)-ZZ)
      ARG=DOM/(RAD1*RAD2)
      IF (ARG .LT. -1.0) ARG=-1.0
      IF (ARG .GT. 1.0) ARG=1.0
      H(I,J)=ACOS(ARG)
      ERR=ERR+(G(I,J)-H(I,J))**2
    1 CONTINUE
      RETURN
      END
```

```
SUBROUTINE FIND(XX,YY,ZZ,FF,ERR,X,Y,Z,P,Q,N,NSTOP,FP,FQ)
DIMENSION X(20),Y(20),Z(20),P(20),Q(20)
M=6
ERS=1000000.0
XM=M
NTRY=1
DUST=(FQ-FP)/XM
DP=1.5
DF=30.1
DPP=DP
CALL HORSY(XX,YY,ZZ,FP,ERR,X,Y,Z,P,Q,N,NSTOP,DPP,DF)
XA=XX
YA=YY
ZA=ZZ
DPP=DP
CALL HORSY(XX,YY,ZZ,FQ,ERR,X,Y,Z,P,Q,N,NSTOP,DPP,DF)
XB=XX
YB=YY
ZB=ZZ
COXB=(XB-XA)/(FQ-FP)
COXA=XA-COXB*FP
COYB=(YB-YA)/(FQ-FP)
COYA=YA-COYB*FP
COZB=(ZB-ZA)/(FQ-FP)
COZA=ZA-COZB*FP
DAST=SQRT((XB-XA)**2+(YB-YA)**2+(ZB-ZA)**2)
SX=(XB-XA)/DAST
SY=(YB-YA)/DAST
SZ=(ZB-ZA)/DAST
```

```
      DOM=SQRT(SX**2+SY**2)
      IF (DOM-0.0001) 50,50,51
   50 TX=1.0-SX**2
      TY=-SX*SY
      TZ=-SX*SZ
      TD=SQRT(TX**2+TY**2+TZ**2)
      TX=TX/TD
      TY=TY/TD
      TZ=TZ/TD
      UX=SY*TZ-SZ*TY
      UY=SZ*TX-SX*TZ
      UZ=SX*TY-SY*TX
      GO TO 52
   51 TX=-SY/DOM
      TY=SX/DOM
      TZ=0.0
      UX=-TY*SZ
      UY=TX*SZ
      UZ=DOM
   52 CODP=DAST/(FQ-FP)
      FS=FP
      K=M+1
    2 DIST=(FQ-FP)/XM
      FF=FP-DIST
      DO 3 I=1,K
      FF=FF+DIST
      XX=COXA+COXB*FF
      YY=COYA+COYB*FF
```

```
      ZZ=COZA+COZB*FF
      DPP=DP
      DPCK=CODP*DIST
      IF (DPCK .LT. DPP) DPP=DPCK
      CALL REFIN(XX,YY,ZZ,FF,ERR,X,Y,Z,P,Q,N,NSTOP,DPP,DF,
     1SX,SY,SZ,TX,TY,TZ,UX,UY,UZ)
      IF (ERR .GT. ERS) GO TO 1
      XS=XX
      YS=YY
      ZS=ZZ
      FS=FF
      ERS=ERR
    1 IF (I .LT. K) GO TO 3
      IF ((ABS(FS-FP) .LT. 0.5*DIST) .OR. (ABS(FS-FQ) .LT. 0.5*DIST))
     1GO TO 1000
      IF (DIST .LT. 0.001) GO TO 900
      FP=FS-DIST
      FQ=FS+DIST
      GO TO 2
    3 CONTINUE
 1000 NSTOP=1
      WRITE(6,1001) FS,FP,FQ,DIST
 1001 FORMAT(11H NO BRACKET,4E13.6)
      IF (ABS(DUST-DIST+0.000001) .GT. 0.00001) GO TO 900
      IF (ABS(FS-FQ+0.000001) .GT. 0.00001) GO TO 300
      NTRY=NTRY+1
      IF (NTRY .GT. 3) GO TO 900
      NSTOP=0
      TEMP=FQ-FP
      FP=FQ-DIST
      FQ=FQ+TEMP-DIST
      GO TO 2
  900 XX=XS
      YY=YS
      ZZ=ZS
      FF=FS
      ERR=ERS
      WRITE(6,901) XX,YY,ZZ,FF,ERR
  901 FORMAT(13H NEW POSITION,5E13.6)
      RETURN
      END
```

```
      SUBROUTINE HORSY(XX,YY,ZZ,FF,ERR,X,Y,Z,P,Q,N,NSTOP,DP,DF)
      DIMENSION X(20),Y(20),Z(20),P(20),Q(20)
      NTR=DF
      KTR=0
      CALL ANGLE(XX,YY,ZZ,FF,ERR,X,Y,Z,P,Q,N)
      WRITE(6,8) XX,YY,ZZ,FF,ERR,DP,DF,KTR
      XS=XX
      YS=YY
      ZS=ZZ
      FT=FF
    1 XT=XX-2.0*DP
      YT=YY-2.0*DP
      ZT=ZZ-2.0*DP
      KTR=KTR+1
      IF (KTR .GT. NTR) GO TO 7
      DO 2 I=1,3
      XT=XT+DP
      DO 3 J=1,3
      YT=YT+DP
      DO 4 K=1,3
      ZT=ZT+DP
      CALL ANGLE(XT,YT,ZT,FT,ERT,X,Y,Z,P,Q,N)
      IF (ERT .GE. ERR) GO TO 4
      XS=XT
      YS=YT
      ZS=ZT
      ERR=ERT
    4 CONTINUE
      ZT=ZT-3.0*DP
    3 CONTINUE
      YT=YT-3.0*DP
    2 CONTINUE
```

```
      IF (ABS(XX-XS) .GT. [illegible]DP) GO TO 6
      IF (ABS(YY-YS) .GT[illegible]*DP) GO TO 6
      IF (ABS(ZZ-ZS) .GT. [illegible]*DP) GO TO 6
      IF (DP .LT. 0.01) GO TO 7
      DP=0.1*DP
    6 XX=XS
      YY=YS
      ZZ=ZS
      GO TO 1
    7 XX=XS
      YY=YS
      ZZ=ZS
      WRITE(6,8) XX,YY,ZZ,FF,ERR,DP,DF,KTR
    8 FORMAT(20H HARSY,XYZFERR,DP,DF,7E13.6,I5)
 1000 RETURN
      END


      SUBROUTINE REFIN(XX,YY,ZZ,FF,ERR,X,Y,Z,P,Q,N,NSTOP,DP,DF,
     1SX,SY,SZ,TX,TY,TZ,UX,UY,UZ)
      DIMENSION X(20),Y(20),Z(20),P(20),Q(20)
      NTR=0
      KTR=1
      CALL ANGLE(XX,YY,ZZ,FF,ERR,X,Y,Z,P,Q,N)
      WRITE(6,11)XX,YY,ZZ,FF,ERR,DP,DF,KTR
   11 FORMAT(20H REFIN,XYZFERR,DP,DF,7E13.6,I5)
      DPO=DP/3.0
      XMO=1.0
    1 XS=XX+XMO*SX*DP
      YS=YY+XMO*SY*DP
      ZS=ZZ+XMO*SZ*DP
      GO TO 20
    2 XS=XX+XMO*TX*DPO
      YS=YY+XMO*TY*DPO
      ZS=ZZ+XMO*TZ*DPO
      GO TO 20
```

```
    3 XS=XX+XMO*UX*DPO
      YS=YY+XMO*UY*DPO
      ZS=ZZ+XMO*UZ*DPO
   20 CALL ANGLE(XS,YS,ZS,FF,ERS,X,Y,Z,P,Q,N)
      NTR=NTR+1
      IF (ERR-ERS) 22,22,21
   21 ERR=ERS
      XX=XS
      YY=YS
      ZZ=ZS
      GO TO (1,2,3),KTR
   22 IF (XMO) 24,23,23
   23 XMO=-1.0
      GO TO (1,2,3) ,KTR
   24 XMO=1.0
      KTR=KTR+1
      IF (KTR .GT. 3) GO TO 25
      GO TO (1,2,3) ,KTR
   25 KTR=1
      DP=0.1*DP
      IF (DP .LT. 0.0009) GO TO 26
      DPO=DP/3.0
      GO TO 1
   26 WRITE(6,11)XX,YY,ZZ,FF,ERR,DP,DF,NTR
      RETURN
      END
```

```
POOCJ  .150167E+00  .213917E+00  .380208E+01  .325500E+00  .376300E+01

POOCJ  .593333E-01  .213750E+00  .380992E+01 -.841167E+00  .376567E+01

POOCJ -.482500E-01 -.261000E+00  .729170E-01  .583330E+00  .648417E+00

POOCJ -.150917E+00 -.156083E+00  .729170E-01 -.552083E+00  .656250E+00

POOCJ -.191833E+00 -.154417E+00  .573330E-01 -.106250E+01  .507830E+00

POOCJ -.103750E+00 -.174583E+00  .833330E-01-0.              .677080E+00

POOCJ -.108667E+00 -.220083E+00  .783300E-02-0.              .291667E+00

HARSY,XYZFERR,DP,DF -.333500E+01  .341917E+01  .354167E+01  .333333E+00  .297780E+01  .150000E+01  .301000E+02    0
HARSY,XYZFERR,DP,DF -.924500E+00  .152467E+01  .331817E+01  .333333E+00  .171491E-01  .150000E-02  .301000E+02   28
HARSY,XYZFERR,DP,DF -.924500E+00  .152467E+01  .331817E+01  .133333E+01  .756289E+01  .150000E+01  .301000E+02    0
HARSY,XYZFERR,DP,DF -.856850E+01  .662317E+01  .543317E+01  .133333E+01  .295171E-03  .150000E-02  .301000E+02   27
REFIN,XYZFERR,DP,DF -.924500E+00  .152467E+01  .331817E+01  .333333E+00  .171491E-01  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.924036E+00  .152496E+01  .331914E+01  .333333E+00  .171491E-01  .150000E-03  .301000E+02   27
REFIN,XYZFERR,DP,DF -.219850E+01  .237442E+01  .367067E+01  .500000E+00  .243319E-02  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.215548E+01  .249658E+01  .339123E+01  .500000E+00  .174561E-02  .150000E-03  .301000E+02  216
REFIN,XYZFERR,DP,DF -.347250E+01  .322417E+01  .402317E+01  .666667E+00  .382324E-03  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.342442E+01  .331531E+01  .383679E+01  .666667E+00  .178362E-03  .150000E-03  .301000E+02  231
REFIN,XYZFERR,DP,DF -.474650E+01  .407392E+01  .437567E+01  .833333E+00  .199998E-03  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.469504E+01  .415499E+01  .424585E+01  .833333E+00  .140222E-03  .150000E-03  .301000E+02  146
REFIN,XYZFERR,DP,DF -.602050E+01  .492367E+01  .472817E+01  .100000E+01  .242601E-03  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.598747E+01  .497557E+01  .467563E+01  .100000E+01  .231222E-03  .150000E-03  .301000E+02   95
REFIN,XYZFERR,DP,DF -.729450E+01  .577342E+01  .508067E+01  .116667E+01  .281015E-03  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.727517E+01  .580320E+01  .505871E+01  .116667E+01  .279285E-03  .150000E-03  .301000E+02   57
REFIN,XYZFERR,DP,DF -.856850E+01  .662317E+01  .543317E+01  .133333E+01  .295171E-03  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.856822E+01  .662359E+01  .543317E+01  .133333E+01  .295171E-03  .150000E-03  .301000E+02   25
REFIN,XYZFERR,DP,DF -.347250E+01  .322417E+01  .402317E+01  .666667E+00  .382324E-03  .523812E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.343219E+01  .330852E+01  .387214E+01  .666667E+00  .213687E-03  .523812E-03  .301000E+02   80
REFIN,XYZFERR,DP,DF -.389717E+01  .350742E+01  .414067E+01  .722222E+00  .255335E-03  .523812E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.385682E+01  .358335E+01  .401006E+01  .722222E+00  .144756E-03  .523812E-03  .301000E+02   73
REFIN,XYZFERR,DP,DF -.432183E+01  .379067E+01  .425817E+01  .777778E+00  .208173E-03  .523812E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.428084E+01  .386617E+01  .415425E+01  .777778E+00  .140402E-03  .523812E-03  .301000E+02   66
REFIN,XYZFERR,DP,DF -.474650E+01  .407392E+01  .437567E+01  .833333E+00  .199998E-03  .523812E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.470356E+01  .414812E+01  .426196E+01  .833333E+00  .153414E-03  .523812E-03  .301000E+02   60
REFIN,XYZFERR,DP,DF -.517117E+01  .435717E+01  .449317E+01  .888889E+00  .209450E-03  .523812E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.513114E+01  .442702E+01  .442276E+01  .888889E+00  .182111E-03  .523812E-03  .301000E+02   52
REFIN,XYZFERR,DP,DF -.559583E+01  .464042E+01  .461067E+01  .944444E+00  .225497E-03  .523812E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.555644E+01  .470649E+01  .454706E+01  .944444E+00  .207094E-03  .523812E-03  .301000E+02   46
REFIN,XYZFERR,DP,DF -.602050E+01  .492367E+01  .472817E+01  .100000E+01  .242601E-03  .523812E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.598271E+01  .498452E+01  .467137E+01  .100000E+01  .230512E-03  .523812E-03  .301000E+02   39
REFIN,XYZFERR,DP,DF -.432183E+01  .379067E+01  .425817E+01  .777778E+00  .208173E-03  .174604E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.426765E+01  .387836E+01  .410252E+01  .777778E+00  .113512E-03  .174604E-03  .301000E+02  142
REFIN,XYZFERR,DP,DF -.446339E+01  .388509E+01  .429734E+01  .796296E+00  .202459E-03  .174604E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.440931E+01  .397215E+01  .415058E+01  .796296E+00  .121039E-03  .174604E-03  .301000E+02  134
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REFIN,XYZFERR,DP,DF -.460494E+01  .397950E+01  .433650E+01  .814815E+00  .199986E-03  .174604E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.455237E+01  .406197E+01  .419542E+01  .814815E+00  .129183E-03  .174604E-03  .301000E+02  125
REFIN,XYZFERR,DP,DF -.474650E+01  .407392E+01  .437567E+01  .833333E+00  .199998E-03  .174604E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.469295E+01  .415643E+01  .423799E+01  .833333E+00  .137415E-03  .174604E-03  .301000E+02  120
REFIN,XYZFERR,DP,DF -.488806E+01  .416834E+01  .441484E+01  .851852E+00  .201888E-03  .174604E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.483515E+01  .424988E+01  .428492E+01  .851852E+00  .148210E-03  .174604E-03  .301000E+02  113
REFIN,XYZFERR,DP,DF -.502961E+01  .426275E+01  .445400E+01  .870370E+00  .205168E-03  .174604E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.497616E+01  .434394E+01  .432693E+01  .870370E+00  .157835E-03  .174604E-03  .301000E+02  108
REFIN,XYZFERR,DP,DF -.517117E+01  .435717E+01  .449317E+01  .888889E+00  .209450E-03  .174604E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.511750E+01  .443751E+01  .436893E+01  .888889E+00  .167817E-03  .174604E-03  .301000E+02  102
NO BRACKET  .777778E+00  .777778E+00  .688889E+00  .185185E-01
NEW POSITION -.426765E+01  .387836E+01  .410252E+01  .777778E+00  .113512E-03
POOCJ -.400833E-01  .215833E+00  .378908E+01  .149210E+01  .376825E+01

POOCJ -.126750E+00  .218000E+00  .380208E+01  .325500E+00  .376300E+01

POOCJ -.230583E+00  .220917E+00  .380992E+01 -.841167E+00  .376567E+01

POOCJ  .156833E+00 -.158417E+00  .546670E-01  .109370E+01  .487000E+00

POOCJ  .116833E+00 -.159167E+00  .729170E-01  .583330E+00  .648417E+00

POOCJ  .672500E-01 -.176917E+00  .833330E-01-0.              .677083E+00

POOCJ  .695833E-01 -.224083E+00  .783300E-02-0.              .291667E+00

HARSY,XYZFERR,DP,DF -.344942E+01 -.349358E+01  .357292E+01  .333333E+00  .379146E+01  .150000E+01  .301000E+02    0
HARSY,XYZFERR,DP,DF -.100592E+01 -.125258E+01  .318592E+01  .333333E+00  .107208E-01  .150000E-02  .301000E+02   30
HARSY,XYZFERR,DP,DF -.100592E+01 -.125258E+01  .318592E+01  .133333E+01  .915475E+01  .150000E+01  .301000E+02    0
HARSY,XYZFERR,DP,DF -.815942E+01 -.719558E+01  .467392E+01  .133333E+01  .459038E-03  .150000E-02  .301000E+02   29
REFIN,XYZFERR,DP,DF -.100592E+01 -.125258E+01  .318592E+01  .333333E+00  .107208E-01  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.100618E+01 -.125214E+01  .318641E+01  .333333E+00  .107208E-01  .150000E-03  .301000E+02   26
REFIN,XYZFERR,DP,DF -.219817E+01 -.224308E+01  .343392E+01  .500000E+00  .102213E-02  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.219119E+01 -.226588E+01  .328146E+01  .500000E+00  .901434E-03  .150000E-03  .301000E+02  103
REFIN,XYZFERR,DP,DF -.339042E+01 -.323358E+01  .368192E+01  .666667E+00  .739412E-04  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.336763E+01 -.326210E+01  .357316E+01  .666667E+00  .268528E-04  .150000E-03  .301000E+02  125
REFIN,XYZFERR,DP,DF -.458267E+01 -.422408E+01  .392992E+01  .833333E+00  .213020E-03  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.453619E+01 -.429402E+01  .386451E+01  .833333E+00  .194705E-03  .150000E-03  .301000E+02   54
REFIN,XYZFERR,DP,DF -.577492E+01 -.521458E+01  .417792E+01  .100000E+01  .365069E-03  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.574110E+01 -.524889E+01  .411802E+01  .100000E+01  .359933E-03  .150000E-03  .301000E+02   54
REFIN,XYZFERR,DP,DF -.696717E+01 -.620508E+01  .442592E+01  .116667E+01  .438761E-03  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.694958E+01 -.622752E+01  .441137E+01  .116667E+01  .437847E-03  .150000E-03  .301000E+02   48
REFIN,XYZFERR,DP,DF -.815942E+01 -.719558E+01  .467392E+01  .133333E+01  .459038E-03  .150000E+01  .301000E+02    1
REFIN,XYZFERR,DP,DF -.815910E+01 -.719596E+01  .467392E+01  .133333E+01  .459038E-03  .150000E-03  .301000E+02   25
REFIN,XYZFERR,DP,DF -.219817E+01 -.224308E+01  .343392E+01  .500000E+00  .102213E-02  .523244E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.219752E+01 -.226295E+01  .332459E+01  .500000E+00  .906490E-03  .523244E-03  .301000E+02   55
REFIN,XYZFERR,DP,DF -.259559E+01 -.257325E+01  .351659E+01  .555556E+00  .387812E-03  .523244E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.258990E+01 -.259573E+01  .342104E+01  .555556E+00  .305357E-03  .523244E-03  .301000E+02   59
REFIN,XYZFERR,DP,DF -.299300E+01 -.290341E+01  .359925E+01  .611111E+00  .137382E-03  .523244E+00  .301000E+02    1
REFIN,XYZFERR,DP,DF -.297755E+01 -.293592E+01  .351059E+01  .611111E+00  .747531E-04  .523244E-03  .301000E+02   54
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REFIN,XYZFERR,DP,DF -.339042E+01 -.323358E+01  .368192E+01  .666667E+00  .739412E-04  .523244E+00  .301000E+02   1
REFIN,XYZFERR,DP,DF -.337396E+01 -.326299E+01  .361048E+01  .666667E+00  .341850E-04  .523244E-03  .301000E+02  52
REFIN,XYZFERR,DP,DF -.378784E+01 -.356375E+01  .376459E+01  .722222E+00  .954083E-04  .523244E+00  .301000E+02   1
REFIN,XYZFERR,DP,DF -.375843E+01 -.360961E+01  .368970E+01  .722222E+00  .617868E-04  .523244E-03  .301000E+02  48
REFIN,XYZFERR,DP,DF -.418525E+01 -.389391E+01  .384725E+01  .777778E+00  .150172E-03  .523244E+00  .301000E+02   1
REFIN,XYZFERR,DP,DF -.415839E+01 -.393282E+01  .378787E+01  .777778E+00  .128443E-03  .523244E-03  .301000E+02  44
REFIN,XYZFERR,DP,DF -.458267E+01 -.422408E+01  .392992E+01  .833333E+00  .213020E-03  .523244E+00  .301000E+02   1
REFIN,XYZFERR,DP,DF -.455273E+01 -.426497E+01  .387743E+01  .833333E+00  .197232E-03  .523244E-03  .301000E+02  42
REFIN,XYZFERR,DP,DF -.299300E+01 -.290341E+01  .359925E+01  .611111E+00  .137382E-03  .174415E+00  .301000E+02   1
REFIN,XYZFERR,DP,DF -.297533E+01 -.292652E+01  .347050E+01  .611111E+00  .715006E-04  .174415E-03  .301000E+02 109
REFIN,XYZFERR,DP,DF -.312548E+01 -.301347E+01  .362661E+01  .629630E+00  .101912E-03  .174415E+00  .301000E+02   1
REFIN,XYZFERR,DP,DF -.310642E+01 -.303694E+01  .350322E+01  .629630E+00  .434739E-04  .174415E-03  .301000E+02 111
REFIN,XYZFERR,DP,DF -.325795E+01 -.312352E+01  .365436E+01  .648148E+00  .819672E-04  .174415E+00  .301000E+02   1
REFIN,XYZFERR,DP,DF -.323819E+01 -.314641E+01  .353652E+01  .648148E+00  .306616E-04  .174415E-03  .301000E+02 101
REFIN,XYZFERR,DP,DF -.339042E+01 -.323358E+01  .368192E+01  .666667E+00  .739412E-04  .174415E+00  .301000E+02   1
REFIN,XYZFERR,DP,DF -.336954E+01 -.326989E+01  .360417E+01  .666667E+00  .299237E-04  .174415E-03  .301000E+02 118
REFIN,XYZFERR,DP,DF -.352289E+01 -.334364E+01  .370948E+01  .685185E+00  .749547E-04  .174415E+00  .301000E+02   1
REFIN,XYZFERR,DP,DF -.349987E+01 -.338195E+01  .363402E+01  .685185E+00  .352779E-04  .174415E-03  .301000E+02 110
REFIN,XYZFERR,DP,DF -.365536E+01 -.345369E+01  .373703E+01  .703704E+00  .827163E-04  .174415E+00  .301000E+02   1
REFIN,XYZFERR,DP,DF -.363020E+01 -.349401E+01  .366387E+01  .703704E+00  .468731E-04  .174415E-03  .301000E+02 111
REFIN,XYZFERR,DP,DF -.378784E+01 -.356375E+01  .376459E+01  .722222E+00  .954083E-04  .174415E+00  .301000E+02   1
REFIN,XYZFERR,DP,DF -.374451E+01 -.363433E+01  .367992E+01  .722222E+00  .575758E-04  .174415E-03  .301000E+02  55
REFIN,XYZFERR,DP,DF -.325795E+01 -.312352E+01  .365436E+01  .648148E+00  .819672E-04  .581382E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.323565E+01 -.316294E+01  .356733E+01  .648148E+00  .293439E-04  .581382E-03  .301000E+02  45
REFIN,XYZFERR,DP,DF -.330211E+01 -.316021E+01  .366355E+01  .654321E+00  .781233E-04  .581382E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.328706E+01 -.318802E+01  .358800E+01  .654321E+00  .351481E-04  .581382E-03  .301000E+02  41
REFIN,XYZFERR,DP,DF -.334626E+01 -.319689E+01  .367273E+01  .660494E+00  .754833E-04  .581382E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.332974E+01 -.322660E+01  .359910E+01  .660494E+00  .334002E-04  .581382E-03  .301000E+02  41
REFIN,XYZFERR,DP,DF -.339042E+01 -.323358E+01  .368192E+01  .666667E+00  .739412E-04  .581382E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.337266E+01 -.326418E+01  .360828E+01  .666667E+00  .327445E-04  .581382E-03  .301000E+02  42
REFIN,XYZFERR,DP,DF -.343458E+01 -.327027E+01  .369111E+01  .672840E+00  .733987E-04  .581382E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.341682E+01 -.330086E+01  .361747E+01  .672840E+00  .340776E-04  .581382E-03  .301000E+02  42
REFIN,XYZFERR,DP,DF -.347873E+01 -.330695E+01  .370029E+01  .679012E+00  .737647E-04  .581382E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.345974E+01 -.333904E+01  .362666E+01  .679012E+00  .352606E-04  .581382E-03  .301000E+02  43
REFIN,XYZFERR,DP,DF -.352289E+01 -.334364E+01  .370948E+01  .685185E+00  .749547E-04  .581382E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.350366E+01 -.337553E+01  .363775E+01  .685185E+00  .381658E-04  .581382E-03  .301000E+02  42
REFIN,XYZFERR,DP,DF -.334626E+01 -.319689E+01  .367273E+01  .660494E+00  .754833E-04  .193794E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.332498E+01 -.323381E+01  .359081E+01  .660494E+00  .286215E-04  .193794E-03  .301000E+02  99
REFIN,XYZFERR,DP,DF -.336098E+01 -.320912E+01  .367580E+01  .662551E+00  .748523E-04  .193794E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.333963E+01 -.324597E+01  .359451E+01  .662551E+00  .286954E-04  .193794E-03  .301000E+02  98
REFIN,XYZFERR,DP,DF -.337570E+01 -.322135E+01  .367886E+01  .664609E+00  .743395E-04  .193794E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.335393E+01 -.325869E+01  .359757E+01  .664609E+00  .285725E-04  .193794E-03  .301000E+02  99
REFIN,XYZFERR,DP,DF -.339042E+01 -.323358E+01  .368192E+01  .666667E+00  .739412E-04  .193794E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.336824E+01 -.327142E+01  .360063E+01  .666667E+00  .285623E-04  .193794E-03  .301000E+02 100
REFIN,XYZFERR,DP,DF -.340514E+01 -.324581E+01  .368498E+01  .668724E+00  .736540E-04  .193794E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.338288E+01 -.328358E+01  .360433E+01  .668724E+00  .289512E-04  .193794E-03  .301000E+02  99
REFIN,XYZFERR,DP,DF -.341986E+01 -.325804E+01  .368804E+01  .670782E+00  .734742E-04  .193794E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.339718E+01 -.329631E+01  .360739E+01  .670782E+00  .291494E-04  .193794E-03  .301000E+02 100
REFIN,XYZFERR,DP,DF -.343458E+01 -.327027E+01  .369111E+01  .672840E+00  .733987E-04  .193794E-01  .301000E+02   1
REFIN,XYZFERR,DP,DF -.341192E+01 -.331023E+01  .361586E+01  .672840E+00  .305367E-04  .193794E-03  .301000E+02 102
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REFIN,XYZFERR,DP,DF -.337570E+01 -.322135E+01  .367886E+01  .664609E+00  .743395E-04  .645980E-02  .301000E+02   1
REFIN,XYZFERR,DP,DF -.336658E+01 -.324457E+01  .362996E+01  .664609E+00  .459363E-04  .645980E-03  .301000E+02  40
REFIN,XYZFERR,DP,DF -.338061E+01 -.322543E+01  .367988E+01  .665295E+00  .741942E-04  .645980E-02  .301000E+02   1
REFIN,XYZFERR,DP,DF -.337123E+01 -.324843E+01  .363310E+01  .665295E+00  .459637E-04  .645980E-03  .301000E+02  39
REFIN,XYZFERR,DP,DF -.338551E+01 -.322950E+01  .368090E+01  .665981E+00  .740615E-04  .645980E-02  .301000E+02   1
REFIN,XYZFERR,DP,DF -.337613E+01 -.325251E+01  .363412E+01  .665981E+00  .460005E-04  .645980E-03  .301000E+02  39
REFIN,XYZFERR,DP,DF -.339042E+01 -.323358E+01  .368192E+01  .666667E+00  .739412E-04  .645980E-02  .301000E+02   1
REFIN,XYZFERR,DP,DF -.338104E+01 -.325658E+01  .363514E+01  .666667E+00  .460490E-04  .645980E-03  .301000E+02  39
REFIN,XYZFERR,DP,DF -.339533E+01 -.323766E+01  .368294E+01  .667353E+00  .738333E-04  .645980E-02  .301000E+02   1
REFIN,XYZFERR,DP,DF -.338595E+01 -.326066E+01  .363616E+01  .667353E+00  .461092E-04  .645980E-03  .301000E+02  39
REFIN,XYZFERR,DP,DF -.340023E+01 -.324173E+01  .368396E+01  .668038E+00  .737376E-04  .645980E-02  .301000E+02   1
REFIN,XYZFERR,DP,DF -.339085E+01 -.326473E+01  .363718E+01  .668038E+00  .461809E-04  .645980E-03  .301000E+02  39
REFIN,XYZFERR,DP,DF -.340514E+01 -.324581E+01  .368498E+01  .668724E+00  .736540E-04  .645980E-02  .301000E+02   1
REFIN,XYZFERR,DP,DF -.339576E+01 -.326881E+01  .363820E+01  .668724E+00  .462641E-04  .645980E-03  .301000E+02  39
NEW POSITION -.336763E+01 -.326210E+01  .357316E+01  .666667E+00  .268528E-04
SERCH  .765517E+00  .576095E+00 -.286528E+00  .666650E+00
SERCH -.336763E+01 -.326210E+01  .357316E+01  .666667E+00  .645135E+00
     -.290601E+00 -.236612E+01  .221354E+01  .799274E-02
X,Y,Z,F,AZ,EL,TILT -.336763E+01 -.326210E+01  .357316E+01  .666667E+00  .645135E+00 -.290601E+00 -.236612E+01
ERROR@ITER.   .553967E-02    0
DANG  .675135E+00 -.290601E+00 -.236612E+01  .142770E+00  .300000E-01  .100000E+01   1
DANG  .615135E+00 -.290601E+00 -.236612E+01  .137032E+00  .300000E-01 -.100000E+01   1
DANG  .645135E+00 -.260601E+00 -.236612E+01  .153933E+00  .300000E-01  .100000E+01   2
DANG  .645135E+00 -.320601E+00 -.236612E+01  .151864E+00  .300000E-01 -.100000E+01   2
DANG  .645135E+00 -.290601E+00 -.233612E+01  .542399E-01  .300000E-01  .100000E+01   3
DANG  .645135E+00 -.290601E+00 -.239612E+01  .439179E-01  .300000E-01 -.100000E+01   3
DANG  .648135E+00 -.290601E+00 -.236612E+01  .171195E-01  .300000E-02  .100000E+01   1
DANG  .642135E+00 -.290601E+00 -.236612E+01  .129730E-01  .300000E-02 -.100000E+01   1
DANG  .645135E+00 -.287601E+00 -.236612E+01  .174169E-01  .300000E-02  .100000E+01   2
DANG  .645135E+00 -.293601E+00 -.236612E+01  .160607E-01  .300000E-02 -.100000E+01   2
DANG  .645135E+00 -.290601E+00 -.236312E+01  .102064E-01  .300000E-02  .100000E+01   3
DANG  .645135E+00 -.290601E+00 -.236912E+01  .484586E-02  .300000E-02 -.100000E+01   3
DANG  .645135E+00 -.290601E+00 -.237212E+01  .790717E-02  .300000E-02 -.100000E+01   3
DANG  .645435E+00 -.290601E+00 -.236912E+01  .550630E-02  .300000E-03  .100000E+01   1
DANG  .644835E+00 -.290601E+00 -.236912E+01  .486589E-02  .300000E-03 -.100000E+01   1
DANG  .645135E+00 -.290301E+00 -.236912E+01  .513745E-02  .300000E-03  .100000E+01   2
DANG  .645135E+00 -.290901E+00 -.236912E+01  .510764E-02  .300000E-03 -.100000E+01   2
DANG  .645135E+00 -.290601E+00 -.236882E+01  .474648E-02  .300000E-03  .100000E+01   3
DANG  .645135E+00 -.290601E+00 -.236852E+01  .470477E-02  .300000E-03  .100000E+01   3
DANG  .645135E+00 -.290601E+00 -.236822E+01  .469106E-02  .300000E-03  .100000E+01   3
DANG  .645135E+00 -.290601E+00 -.236792E+01  .469564E-02  .300000E-03  .100000E+01   3
DANG  .645135E+00 -.290601E+00 -.236852E+01  .470477E-02  .300000E-03 -.100000E+01   3
DANG  .645165E+00 -.290601E+00 -.236822E+01  .474774E-02  .300000E-04  .100000E+01   1
DANG  .645105E+00 -.290601E+00 -.236822E+01  .463811E-02  .300000E-04 -.100000E+01   1
DANG  .645075E+00 -.290601E+00 -.236822E+01  .458907E-02  .300000E-04 -.100000E+01   1
DANG  .645045E+00 -.290601E+00 -.236822E+01  .454415E-02  .300000E-04 -.100000E+01   1
DANG  .645015E+00 -.290601E+00 -.236822E+01  .450367E-02  .300000E-04 -.100000E+01   1
DANG  .644985E+00 -.290601E+00 -.236822E+01  .446817E-02  .300000E-04 -.100000E+01   1
DANG  .644955E+00 -.290601E+00 -.236822E+01  .443865E-02  .300000E-04 -.100000E+01   1
DANG  .644925E+00 -.290601E+00 -.236822E+01  .441708E-02  .300000E-04 -.100000E+01   1
```

```
DANG  .644895E+00 -.290601E+00 -.236822E+01  .440665E-02  .300000E-04 -.100000E+01    1
DANG  .644865E+00 -.290601E+00 -.236822E+01  .440925E-02  .300000E-04 -.100000E+01    1
DANG  .644895E+00 -.290571E+00 -.236822E+01  .446081E-02  .300000E-04  .100000E+01    2
DANG  .644895E+00 -.290631E+00 -.236822E+01  .435426E-02  .300000E-04 -.100000E+01    2
DANG  .644895E+00 -.290661E+00 -.236822E+01  .430416E-02  .300000E-04 -.100000E+01    2
DANG  .644895E+00 -.290691E+00 -.236822E+01  .429681E-02  .300000E-04 -.100000E+01    2
DANG  .644895E+00 -.290721E+00 -.236822E+01  .429358E-02  .300000E-04 -.100000E+01    2
DANG  .644895E+00 -.290751E+00 -.236822E+01  .429285E-02  .300000E-04 -.100000E+01    2
DANG  .644895E+00 -.290781E+00 -.236822E+01  .429495E-02  .300000E-04 -.100000E+01    2
DANG  .644895E+00 -.290751E+00 -.236819E+01  .428149E-02  .300000E-04  .100000E+01    3
DANG  .644895E+00 -.290751E+00 -.236816E+01  .427080E-02  .300000E-04  .100000E+01    3
DANG  .644895E+00 -.290751E+00 -.236813E+01  .426085E-02  .300000E-04  .100000E+01    3
DANG  .644895E+00 -.290751E+00 -.236810E+01  .425169E-02  .300000E-04  .100000E+01    3
DANG  .644895E+00 -.290751E+00 -.236807E+01  .424338E-02  .300000E-04  .100000E+01    3
DANG  .644895E+00 -.290751E+00 -.236804E+01  .423594E-02  .300000E-04  .100000E+01    3
DANG  .644895E+00 -.290751E+00 -.236801E+01  .422939E-02  .300000E-04  .100000E+01    3
DANG  .644895E+00 -.290751E+00 -.236798E+01  .422373E-02  .300000E-04  .100000E+01    3
DANG  .644895E+00 -.290751E+00 -.236795E+01  .421891E-02  .300000E-04  .100000E+01    3
DANG  .644895E+00 -.290751E+00 -.236792E+01  .421490E-02  .300000E-04  .100000E+01    3
DANG  .644895E+00 -.290751E+00 -.236789E+01  .421164E-02  .300000E-04  .100000E+01    3
READ PT. PIERCE PT.,ERROR    1 -.400833E-01  .215833E+00 -.395739E-01  .216441E+00  .793244E-03
ITH OBJECT POINT AND DISTANCE VECTOR
   1  .378908E+01  .149210E+01  .376825E+01  .361385E-02 -.516666E-02 -.712783E-02  .951632E-02
READ PT. PIERCE PT.,ERROR    2 -.126750E+00  .218000E+00 -.126736E+00  .217987E+00  .186950E-04
ITH OBJECT POINT AND DISTANCE VECTOR
   2  .380208E+01  .325500E+00  .376300E+01  .619822E-04 -.131012E-03  .134775E-03  .197915E-03
READ PT. PIERCE PT.,ERROR    3 -.230583E+00  .220917E+00 -.230635E+00  .220655E+00  .267077E-03
ITH OBJECT POINT AND DISTANCE VECTOR
   3  .380992E+01 -.841167E+00  .376567E+01 -.294285E-03  .665930E-03  .256087E-02  .266235E-02
READ PT. PIERCE PT.,ERROR    4  .156833E+00 -.158417E+00  .156881E+00 -.158629E+00  .217765E-03
ITH OBJECT POINT AND DISTANCE VECTOR
   4  .546670E-01  .109370E+01  .487000E+00  .987714E-03  .340796E-03  .157745E-02  .189211E-02
READ PT. PIERCE PT.,ERROR    5  .116833E+00 -.159167E+00  .116832E+00 -.159100E+00  .663036E-04
ITH OBJECT POINT AND DISTANCE VECTOR
   5  .729170E-01  .583330E+00  .648417E+00 -.214034E-03 -.171378E-03 -.477003E-03  .550193E-03
READ PT. PIERCE PT.,ERROR    6  .672500E-01 -.176917E+00  .652506E-01 -.177516E+00  .208735E-02
ITH OBJECT POINT AND DISTANCE VECTOR
   6  .833330E-01-0.               .677083E+00 -.870255E-02  .134546E-01  .488198E-02  .167509E-01
READ PT. PIERCE PT.,ERROR    7  .695833E-01 -.224083E+00  .699013E-01 -.223508E+00  .657594E-03
ITH OBJECT POINT AND DISTANCE VECTOR
   7  .783300E-02-0.               .291667E+00 -.264507E-03 -.353976E-02 -.378272E-02  .518737E-02
X,Y,Z,F,AZ,EL,TILT -.336763E+01 -.326210E+01  .357316E+01  .666667E+00  .644790E+00 -.290829E+00 -.236778E+01
ERRORDITER.  .410803E-02  137
DAMG,THI,PHI,TILT  .221372E+01  .624956E-02  .652351E-02
NORMAL COMPLETION
```

APPENDIX F

PROGRAM SLED AND TYPICAL LISTING OF SOLUTIONS

```
      PROGRAM SLED(INPUT,OUTPUT,PUNCH,TAPE5=INPUT,TAPE6=OUTPUT,
     1TAPE7=PUNCH)
      COMMON RAA,RAB,RAC,FA,THA,PHA,GA,RBA,RBB,RBC,FB,THB,PHB,
     1GB,THIA,PHIA,THIB,PHIB
      DIMENSION NFRA(150),NFRB(150),XA(150,8),YA(150,8),XB(150,8),
     1YB(150,8),TA(150),TB(150),XX(10),YY(10),ZZ(10),TREFA(10),
     2TREFB(10),NREFA(10),NREFB(10),SMEAN(8),SSDEV(8)
    1 READ(5,2)RAA,RAB,RAC,FA,THA,PHA,GA,THIA,PHIA
      ICHK=EOF(5)
      IF(ICHK.NE.0) GO TO 999
      NCHK=0
      READ(5,2)RBA,RBB,RBC,FB,THB,PHB,GB,THIB,PHIB
 2    FORMAT(4F10.0/5F10.0)
      NA=0
      NB=0
 3    NA=NA+1
      READ(5,4) NFRA(NA),((XA(NA,I),YA(NA,I)),I=1,8)
 4    FORMAT(I5,8F7.0/5X,8F7.0)
      IF(NFRA(NA).NE.99999) GO TO 3
      NA=NA-1
      DO 100 I=1,NA
      DO 100 J=1,8
      XA(I,J)=-XA(I,J)/12000.0
  100 YA(I,J)=YA(I,J)/12000.0
 5    NB=NB+1
      READ(5,4)NFRB(NB),((XB(NB,I),YB(NB,I)),I=1,8)
      IF(NFRB(NB).NE.99999) GO TO 5
      NB=NB-1
      DO 101 I=1,NB
      DO 101 J=1,8
      XB(I,J)=-XB(I,J)/12000.0
  101 YB(I,J)=YB(I,J)/12000.0
      NHP=0
 6    NHP=NHP+1
      READ(5,7)XX(NHP),YY(NHP),ZZ(NHP)
 7    FORMAT(3F10.0)
      IF(XX(NHP).LT.99999.0) GO TO 6
      NHP=NHP-1
      WRITE(6,8)RAA,RAB,RAC,FA,THA,PHA,GA,THIA,PHIA
```

```
      WRITE(6,8)RBA,RBB,RBC,FB,THB,PHB,GB,TH1B,PH1B
    8 FORMAT(12H CAMERA DATA/9E13.6)
      DO 9 I=1,NHP
      WRITE(6,10) XX(I),YY(I),ZZ(I)
   10 FORMAT(18H HARD PT LOCATIONS,3E13.6)
    9 CONTINUE
      NTMA=0
   11 NTMA=NTMA+1
      READ(5,12) TREFA(NTMA),NREFA(NTMA)
   12 FORMAT(F10.0,I6)
      IF(NREFA(NTMA).LT.99999) GO TO 11
      NTMA=NTMA-1
      NTMB=0
   13 NTMB=NTMB+1
      READ(5,12) TREFB(NTMB),NREFB(NTMB)
      IF(NREFB(NTMB).LT.99999) GO TO 13
      NTMB=NTMB-1
      DO 14 I=1,NTMA
      WRITE(6,15) TREFA(I),NREFA(I),NTMA
   15 FORMAT(20H REF TIMES&FRAME NOS,E13.6,2I5)
   14 CONTINUE
      DO 16 I=1,NTMB
      WRITE(6,15) TREFB(I),NREFB(I),NTMB
   16 CONTINUE
      CALL TMSGN(NTMA,NA,NREFA,TREFA,NFRA,TA)
      CALL TMSGN(NTMB,NB,NREFB,TREFB,NFRB,TB)
      DO 17 I=1,NA
      WRITE(6,18)I,NFRA(I),TA(I),((XA(I,J),YA(I,J)),J=1,8)
   18 FORMAT ( 2I6,E13.6/8E13.6/8E13.6)
   17 CONTINUE
      DO 19 I=1,NB
      WRITE(6,18) I,NFRB(I),TB(I),((XB(I,J),YB(I,J)),J=1,8)
   19 CONTINUE
      READ(5,20)DT,DESIG
   20 FORMAT(2F10.0)
      WRITE(6,21) DT
   21 FORMAT(15H TIME INCREMENT,E13.6)
      CALL ALL(NA,NB,TA,TB,NFRA,NFRB,XA,YA,XB,YB,SMEAN,SSDEV,
     1DT,XX,YY,ZZ,DESIG,NCHK)
      GO TO 1
  999 WRITE(6,1000)
 1000 FORMAT(18H NORMAL COMPLETION)
      STOP
      END
```

```
      BOT=SIN(TH)
      AA=SIN(THT)/BOT
      BB=SIN(THS)/BOT
      TF=AA*RF+BB*SF
      TI=AA*RI+BB*SI
      TJ=AA*RJ+BB*SJ
      TIM=SQRT(TF**2+TI**2+TJ**2)
      XK=F/TF
      P=XK*TI
      Q=XK*TJ
      GO TO 1000
    1 P=PPA
      Q=QQA
 1000 RETURN
      END
      SUBROUTINE SOLVE(PA,QA,PB,QB,NT,SOLA,SOLB,SOLC,D,J,NCHK,NTR)
      COMMON RAA,RAB,RAC,FA,THA,PHA,GA,RBA,RBB,RBC,FB,THB,PHB,
     1GB,THIA,PHIA,THIB,PHIB
      IF (NT .GT. 0) GO TO 1
      IF (NCHK .EQ. 0) GO TO 2
      THA=THAP
      PHA=PHAP
      THIA=THIAP
      PHIA=PHIAP
      THB=THBP
      PHB=PHBP
      THIB=THIBP
      PHIB=PHIBP
      GA=GAP
      GB=GBP
    2 FAA=FA*COS(THA)*COS(PHA)
      FAB=FA*SIN(THA)*COS(PHA)
      FAC=FA*SIN(PHA)
      FBA=FB*COS(THB)*COS(PHB)
      FBB=FB*SIN(THB)*COS(PHB)
      FBC=FB*SIN(PHB)
      FAAB=ABS(FA)
      FBAB=ABS(FB)
      CHKA=(FAA*FBA+FAB*FBB+FAC*FBC)/(FAAB*FBAB)
      IF (CHKA .GT. 1.0) CHKA=1.0
      IF (CHKA .LT. -1.0) CHKA=-1.0
      CHAN=ACOS(CHKA)
      IF (CHAN .LT. 1.57079) GO TO 101
      WRITE(6.102) FA.THA.PHA.FB.THB.PHB.CHAN
```

```
      SUBROUTINE TMSGN(NTM,N,NREF,TREF,NFR,T)
      DIMENSION NREF(10),TREF(10),NFR(150),T(150)
      NST=NTM-1
      DO 2 J=1,NST
      K=J+1
      DO 4 L=1,N
      IF (NFR(L) .NE. NREF(K)) GO TO 4
      M=L
      GO TO 7
    4 CONTINUE
    7 IF (J .EQ. 1) NB=1
      IF(K.EQ.NTM) GO TO 3
      NE=M
      GO TO 6
    3 NE=N
    6 DNU=TREF(K)-TREF(J)
      DEN=NREF(K)-NREF(J)
      FRA=DNU/DEN
      DO 5 I=NB,NE,1
      FAC=M-I
    5 T(I)=TREF(K)-FRA*FAC
      IF(NE.EQ.N) GO TO 1000
      NB=NE
    2 CONTINUE
 1000 RETURN
      END
      SUBROUTINE FIND(F,PPA,QQA,PPB,QQB,TS,TAS,TBS,P,Q)
      R=ABS(PPA-PPB)
      S=ABS( QQA-QQB)
      IF((R.LT.0.000001).AND.(S.LT.0.000001)) GO TO 1
      WRITE(6,100)TAS,PPA,QQA,PPB,QQB,TS
  100 FORMAT(5H FIND,6E13.6)
      R=SQRT(F**2+PPA**2+QQA**2)
      S=SQRT(F**2+PPB**2+QQB**2)
      RF=F/R
      RI=PPA/R
      RJ=QQA/R
      SF=F/S
      SI=PPB/S
      SJ=QQB/S
      ARGU=SQRT((RI*SJ-RJ*SI)**2+(RJ*SF-RF*SJ)**2+(RF*SI-RI*SF)**2)
      TH=ASIN(ARGU)
      THS=(TS-TAS)*TH/(TBS-TAS)
      THT=TH-THS
```

```
      RNC=RNC/DRN
      D=(RAA-RBA)*RNA+(RAB-RBB)*RNB+(RAC-RBC)*RNC
      O=SAA*SBA+SAB*SBB+SAC*SBC
      P=(RBA-RAA)*SAA+(RBB-RAB)*SAB+(RBC-RAC)*SAC
      Q=(RBA-RAA)*SBA+(RBB-RAB)*SBB+(RBC-RAC)*SBC
      COB=(P*O-Q)/(1.0-O**2)
      COA=P+COB*O
      SOLA=RBA+COB*SBA+0.5*D*RNA
      SOLB=RBB+COB*SBB+0.5*D*RNB
      SOLC=RBC+COB*SBC+0.5*D*RNC
      SOLD=RAA+COA*SAA-0.5*D*RNA
      SOLE=RAB+COA*SAB-0.5*D*RNB
      SOLF=RAC+COA*SAC-0.5*D*RNC
      RRNA=D*RNA
      RRNB=D*RNB
      RRNC=D*RNC
      IF (NCHK .GT. 0) GO TO 1000
      CALL CORR(SOLA,SOLB,SOLC,PA,QA,PB,QB,D,J,NTR,NT,THAP,
     1PHAP,THIAP,PHIAP,GAP,THBP,PHBP,THIBP,PHIBP,GBP,SAA,SAB,
     2SAC,SBA,SBB,SBC,AIA,AIB,AIC,AJA,AJB,AJC,BIA,BIB,BIC,BJA,BJB,BJC)
 1000 RETURN
      END
      SUBROUTINE CORR(SOLA,SOLB,SOLC,PA,QA,PB,QB,D,J,NTR,NT,THAP,
     1PHAP,THIAP,PHIAP,GAP,THBP,PHBP,THIBP,PHIBP,GBP,SAA,SAB,
     2SAC,SBA,SBB,SBC,AIA,AIB,AIC,AJA,AJB,AJC,BIA,BIB,BIC,BJA,BJB,BJC)
      COMMONRAA,RAB,RAC,FA,THA,PHA,GA,RBA,RBB,RBC,FB,THB,PHB,
     1GB,THIA,PHIA,THIB,PHIB
     0DIMENSION T(3,4),SA(3,4),SB(3,4),DERR(4),TA(3,4),TB(3,4),
     1TAE(3),TAF(3),TBE(3),TBF(3),SAE(3),SAF(3),SBE(3),SBF(3),
     2TAG(3),TBG(3),SAG(3),SBG(3),TAH(3),TBH(3),SAH(3),SBH(3),
     3TAI(3),TBI(3),SAI(3),SBI(3)
      IF (NT .GT. 0) GO TO 1
      FAE=COS(THA)*COS(PHA)
      FAN=SIN(THA)*COS(PHA)
      FAH=SIN(PHA)
      FBE=COS(THB)*COS(PHB)
      FBN=SIN(THB)*COS(PHB)
      FBH=SIN(PHB)
      STHAP=0.0
      SPHAP=0.0
      SGAP=0.0
      STHBP=0.0
      SPHBP=0.0
      SGBP=0.0
```

```
102 FORMAT(35H BAD CAMERA DATA PROBABLE SEE SOLVE/7E13.6)
101 CONTINUE
    AIA=COS(THIA)*COS(PHIA)
    AIB=SIN(THIA)*COS(PHIA)
    AIC=SIN(PHIA)
    BIA=COS(THIB)*COS(PHIB)
    BIB=SIN(THIB)*COS(PHIB)
    BIC=SIN(PHIB)
    AJA=(FAB*AIC-FAC*AIB)/FA
    AJB=(FAC*AIA-FAA*AIC)/FA
    AJC=(FAA*AIB-FAB*AIA)/FA
    BJA=(FBB*BIC-FBC*BIB)/FB
    BJB=(FBC*BIA-FBA*BIC)/FB
    BJC=(FBA*BIB-FBB*BIA)/FB
  1 SAA=FAA+PA*AIA+QA*AJA
    WRITE(6,105) PA,QA,PB,QB,SOLA,SOLB,SOLC,NT
105 FORMAT(6H SOLVE,7E13.6,I5)
    SAB=FAB+PA*AIB+QA*AJB
    SAC=FAC+PA*AIC+QA*AJC
    SBA=FBA+PB*BIA+QB*BJA
    SBB=FBB+PB*BIB+QB*BJB
    SBC=FBC+PB*BIC+QB*BJC
    DSA=SQRT(SAA**2+SAB**2+SAC**2)
    DSB=SQRT(SBA**2+SBB**2+SBC**2)
    SAA=SAA/DSA
    SAB=SAB/DSA
    SAC=SAC/DSA
    SBA=SBA/DSB
    SBB=SBB/DSB
    SBC=SBC/DSB
    CHKA=SAA*SBA+SAB*SBB+SAC*SBC
    IF (CHKA .GT. 1.0) CHKA=1.0
    IF (CHKA .LT. -1.0) CHKA=-1.0
    CHAN=ACOS(CHKA)
    IF (CHAN .LT. 1.57079) GO TO 103
    WRITE(6,104) PA,QA,PB,QB,CHAN
104 FORMAT(39H BAD FILM FRAME DATA PROBABLE SEE SOLVE,5E13.6)
103 CONTINUE
    RNA=SAB*SBC-SAC*SBB
    RNB=SAC*SBA-SAA*SBC
    RNC=SAA*SBB-SAB*SBA
    DRN=SQRT(RNA**2+RNB**2+RNC**2)
    RNA=RNA/DRN
    RNB=RNB/DRN
```

```
      DTBF=SQRT(TBF(1)**2+TBF(2)**2+TBF(3)**2)
      DSAE=SQRT(SAE(1)**2+SAE(2)**2+SAE(3)**2)
      DSAF=SQRT(SAF(1)**2+SAF(2)**2+SAF(3)**2)
      DSBE=SQRT(SBE(1)**2+SBE(2)**2+SBE(3)**2)
      DSBF=SQRT(SBF(1)**2+SBF(2)**2+SBF(3)**2)
      DO 8 I=1,3
      TAE(I)=TAE(I)/DTAE
      TAF(I)=TAF(I)/DTAF
      TBE(I)=TBE(I)/DTBE
      TBF(I)=TBF(I)/DTBF
      SAE(I)=SAE(I)/DSAE
      SAF(I)=SAF(I)/DSAF
      SBE(I)=SBE(I)/DSBE
      SBF(I)=SBF(I)/DSBF
    8 CONTINUE
      DO 9 I=1,3
      TAG(I)=TAE(I)+TAF(I)
      TBG(I)=TBE(I)+TBF(I)
      SAG(I)=SAE(I)+SAF(I)
      SBG(I)=SBE(I)+SBF(I)
    9 CONTINUE
      DTAG=SQRT(TAG(1)**2+TAG(2)**2+TAG(3)**2)
      DTBG=SQRT(TBG(1)**2+TBG(2)**2+TBG(3)**2)
      DSAG=SQRT(SAG(1)**2+SAG(2)**2+SAG(3)**2)
      DSBG=SQRT(SBG(1)**2+SBG(2)**2+SBG(3)**2)
      DO 6 I=1,3
      TAG(I)=TAG(I)/DTAG
      TBG(I)=TBG(I)/DTBG
      SAG(I)=SAG(I)/DSAG
      SBG(I)=SBG(I)/DSBG
    6 CONTINUE
      TAH(1)=TAE(2)*TAF(3)-TAE(3)*TAF(2)
      TBH(1)=TBE(2)*TBF(3)-TBE(3)*TBF(2)
      SAH(1)=SAE(2)*SAF(3)-SAE(3)*SAF(2)
      SBH(1)=SBE(2)*SBF(3)-SBE(3)*SBF(2)
      TAH(2)=TAE(3)*TAF(1)-TAE(1)*TAF(3)
      TBH(2)=TBE(3)*TBF(1)-TBE(1)*TBF(3)
      SAH(2)=SAE(3)*SAF(1)-SAE(1)*SAF(3)
      SBH(2)=SBE(3)*SBF(1)-SBE(1)*SBF(3)
      TAH(3)=TAE(1)*TAF(2)-TAE(2)*TAF(1)
      TBH(3)=TBE(1)*TBF(2)-TBE(2)*TBF(1)
      SAH(3)=SAE(1)*SAF(2)-SAE(2)*SAF(1)
      SBH(3)=SBE(1)*SBF(2)-SBE(2)*SBF(1)
```

```
1 K=J-4
  T(1,K)=SOLA
  T(2,K)=SOLB
  T(3,K)=SOLC
  SA(1,K)=SAA
  SA(2,K)=SAB
  SA(3,K)=SAC
  SB(1,K)=SBA
  SB(2,K)=SBB
  SB(3,K)=SBC
  DERR(K)=0
  IF (K .LT. 4) GO TO 1000
  DO 2 I=1,4
  IF (DERR(I) .GT. 0.75) GO TO 1000
2 CONTINUE
  NTR=NTR+1
  DO 3 I=1,4
  TA(1,I)=T(1,I)-RAA
  TA(2,I)=T(2,I)-RAB
  TA(3,I)=T(3,I)-RAC
  TB(1,I)=T(1,I)-RBA
  TB(2,I)=T(2,I)-RBB
  TB(3,I)=T(3,I)-RBC
  DAM=SQRT(TA(1,I)**2+TA(2,I)**2+TA(3,I)**2)
  DBM=SQRT(TB(1,I)**2+TB(2,I)**2+TB(3,I)**2)
  TA(1,I)=TA(1,I)/DAM
  TA(2,I)=TA(2,I)/DAM
  TA(3,I)=TA(3,I)/DAM
  TB(1,I)=TB(1,I)/DBM
  TB(2,I)=TB(2,I)/DBM
  TB(3,I)=TB(3,I)/DBM
3 CONTINUE
  DO 4 I=1,3
  TAE(I)=TA(I,1)+TA(I,2)
  TAF(I)=TA(I,3)+TA(I,4)
  TBE(I)=TB(I,1)+TB(I,2)
  TBF(I)=TB(I,3)+TB(I,4)
  SAE(I)=SA(I,1)+SA(I,2)
  SAF(I)=SA(I,3)+SA(I,4)
  SBE(I)=SB(I,1)+SB(I,2)
  SBF(I)=SB(I,3)+SB(I,4)
4 CONTINUE
  DTAE=SQRT(TAE(1)**2+TAE(2)**2+TAE(3)**2)
  DTAF=SQRT(TAF(1)**2+TAF(2)**2+TAF(3)**2)
  DTBE=SQRT(TBE(1)**2+TBE(2)**2+TBE(3)**2)
```

```
BIGG=BIA*SBG(1)+BIB*SBG(2)+BIC*SBG(3)
BIII=BIA*SBI(1)+BIB*SBI(2)+BIC*SBI(3)
BIHH=BIA*SBH(1)+BIB*SBH(2)+BIC*SBH(3)
BJGG=BJA*SBG(1)+BJB*SBG(2)+BJC*SBG(3)
BJII=BJA*SBI(1)+BJB*SBI(2)+BJC*SBI(3)
BJHH=BJA*SBH(1)+BJB*SBH(2)+BJC*SBH(3)
FBXX=FBGG*TBG(1)+FBII*TBI(1)+FBHH*TBH(1)
FBYY=FBGG*TBG(2)+FBII*TBI(2)+FBHH*TBH(2)
FBZZ=FBGG*TBG(3)+FBII*TBI(3)+FBHH*TBH(3)
BIXX=BIGG*TBG(1)+BIII*TBI(1)+BIHH*TBH(1)
BIYY=BIGG*TBG(2)+BIII*TBI(2)+BIHH*TBH(2)
BIZZ=BIGG*TBG(3)+BIII*TBI(3)+BIHH*TBH(3)
BJXX=BJGG*TBG(1)+BJII*TBI(1)+BJHH*TBH(1)
BJYY=BJGG*TBG(2)+BJII*TBI(2)+BJHH*TBH(2)
BJZZ=BJGG*TBG(3)+BJII*TBI(3)+BJHH*TBH(3)
THBP=ACOS(FBXX/SQRT(FBXX**2+FBYY**2))
IF (FBYY .LT. 0.0) THBP=-THBP
PHBP=ASIN(FBZZ)
THAP=ACOS(FAXX/SQRT(FAXX**2+FAYY**2))
IF (FAYY .LT. 0.0) THAP=-THAP
PHAP=ASIN(FAZZ)
DFA=SQRT(FAXX**2+FAYY**2)
FAHX=-FAYY/DFA
FAHY=FAXX/DFA
GAP=ACOS(AIXX*FAHX+AIYY*FAHY)
IF (AIZZ .LT. 0.0) GAP=-GAP
DFB=SQRT(FBXX**2+FBYY**2)
FBHX=-FBYY/DFB
FBHY=FBXX/DFB
GBP=ACOS(BIXX*FBHX+BIYY*FBHY)
IF (BIZZ .LT. 0.0) GBP=-GBP
STHAP=STHAP+THAP
SPHAP=SPHAP+PHAP
SGAP=SGAP+GAP
STHBP=STHBP+THBP
SPHBP=SPHBP+PHBP
SGBP=SGBP+GBP
XNTR=NTR
THAP=STHAP/XNTR
PHAP=SPHAP/XNTR
GAP=SGAP/XNTR
THBP=STHBP/XNTR
PHBP=SPHBP/XNTR
GBP=SGBP/XNTR
FAXX=COS(THAP)*COS(PHAP)
```

```
      DTAH=SQRT(TAH(1)**2+TAH(2)**2+TAH(3)**2)
      DTBH=SQRT(TBH(1)**2+TBH(2)**2+TBH(3)**2)
      DSAH=SQRT(SAH(1)**2+SAH(2)**2+SAH(3)**2)
      DSBH=SQRT(SBH(1)**2+SBH(2)**2+SBH(3)**2)
      DO 7 I=1,3
      TAH(I)=TAH(I)/DTAH
      TBH(I)=TBH(I)/DTBH
      SAH(I)=SAH(I)/DSAH
      SBH(I)=SBH(I)/DSBH
    7 CONTINUE
      TAI(1)=TAH(2)*TAG(3)-TAH(3)*TAG(2)
      TAI(2)=TAH(3)*TAG(1)-TAH(1)*TAG(3)
      TAI(3)=TAH(1)*TAG(2)-TAH(2)*TAG(1)
      TBI(1)=TBH(2)*TBG(3)-TBH(3)*TBG(2)
      TBI(2)=TBH(3)*TBG(1)-TBH(1)*TBG(3)
      TBI(3)=TBH(1)*TBG(2)-TBH(2)*TBG(1)
      SAI(1)=SAH(2)*SAG(3)-SAH(3)*SAG(2)
      SAI(2)=SAH(3)*SAG(1)-SAH(1)*SAG(3)
      SAI(3)=SAH(1)*SAG(2)-SAH(2)*SAG(1)
      SBI(1)=SBH(2)*SBG(3)-SBH(3)*SBG(2)
      SBI(2)=SBH(3)*SBG(1)-SBH(1)*SBG(3)
      SBI(3)=SBH(1)*SBG(2)-SBH(2)*SBG(1)
      FAGG=FAE*SAG(1)+FAN*SAG(2)+FAH*SAG(3)
      FAII=FAE*SAI(1)+FAN*SAI(2)+FAH*SAI(3)
      FAHH=FAE*SAH(1)+FAN*SAH(2)+FAH*SAH(3)
      AIGG=AIA*SAG(1)+AIB*SAG(2)+AIC*SAG(3)
      AIII=AIA*SAI(1)+AIB*SAI(2)+AIC*SAI(3)
      AIHH=AIA*SAH(1)+AIB*SAH(2)+AIC*SAH(3)
      AJGG=AJA*SAG(1)+AJB*SAG(2)+AJC*SAG(3)
      AJII=AJA*SAI(1)+AJB*SAI(2)+AJC*SAI(3)
      AJHH=AJA*SAH(1)+AJB*SAH(2)+AJC*SAH(3)
      FAXX=FAGG*TAG(1)+FAII*TAI(1)+FAHH*TAH(1)
      FAYY=FAGG*TAG(2)+FAII*TAI(2)+FAHH*TAH(2)
      FAZZ=FAGG*TAG(3)+FAII*TAI(3)+FAHH*TAH(3)
      AIXX=AIGG*TAG(1)+AIII*TAI(1)+AIHH*TAH(1)
      AIYY=AIGG*TAG(2)+AIII*TAI(2)+AIHH*TAH(2)
      AIZZ=AIGG*TAG(3)+AIII*TAI(3)+AIHH*TAH(3)
      AJXX=AJGG*TAG(1)+AJII*TAI(1)+AJHH*TAH(1)
      AJYY=AJGG*TAG(2)+AJII*TAI(2)+AJHH*TAH(2)
      AJZZ=AJGG*TAG(3)+AJII*TAI(3)+AJHH*TAH(3)
      FBGG=FBE*SBG(1)+FBN*SBG(2)+FBH*SBG(3)
      FBII=FBE*SBI(1)+FBN*SBI(2)+FBH*SBI(3)
      FBHH=FBE*SBH(1)+FBN*SBH(2)+FBH*SBH(3)
```

```
     2,TIM(150),X(150,4),Y(150,4),Z(150,4),DD(150,4)
   9 NT=-1
     NTR=0
     TS=AMAX1(TA(1),TB(1))
     N=TS/DT
     XN=N
     TS=XN*DT
     NTESP=0
     NAS=1
     NBS=1
     DO 8 J=1,8
     SMEAN(J)=0.0
   8 SSDEV(J)=0.0
   1 TS=TS+DT
     IF(TS.GT.AMAX1(TA(1),TB(1))) GO TO 2
     GO TO 1
   2 IF(TS.GT.AMIN1(TA(NA),TB(NB))) GO TO 1000
     DO 3 I=NAS,NA,1
     IF(TS.GE.TA(I)) GO TO 3
     GO TO 4
   3 CONTINUE
   4 NAS=I-1
     DO 5 I=NBS,NB,1
     IF(TS.GE.TB(I)) GO TO 5
     GO TO 6
   5 CONTINUE
   6 NBS=I-1
     DO 7 J=5,8,1
     PPA=XA(NAS,J)
     QQA=YA(NAS,J)
     PPB=XA(NAS+1,J)
     QQB=YA(NAS+1,J)
     TAS=TA(NAS)
     TBS=TA(NAS+1)
     CALL FIND(FA,PPA,QQA,PPB,QQB,TS,TAS,TBS,P,Q)
     PA=P
     QA=Q
     PPA=XB(NBS,J)
     QQA=YB(NBS,J)
     PPB=XB(NBS+1,J)
     QQB=YB(NBS+1,J)
     TAS=TB(NBS)
     TBS=TB(NBS+1)
     CALL FIND(FB,PPA,QQA,PPB,QQB,TS,TAS,TBS,P,Q)
```

```
      FAYY=SIN(THAP)*COS(PHAP)
      FAZZ=SIN(PHAP)
      FBXX=COS(THBP)*COS(PHBP)
      FBYY=SIN(THBP)*COS(PHBP)
      FBZZ=SIN(PHBP)
      DFA=SQRT(FAXX**2+FAYY**2)
      FAHX=-FAYY/DFA
      FAHY=FAXX/DFA
      FAVX=-FAHY*FAZZ
      FAVY=FAHX*FAZZ
      FAVZ=FAHY*FAXX-FAHX*FAYY
      COGAP=COS(GAP)
      SIGAP=SIN(GAP)
      AIXX=COGAP*FAHX+SIGAP*FAVX
      AIYY=COGAP*FAHY+SIGAP*FAVY
      AIZZ=SIGAP*FAVZ
      THIAP=ACOS(AIXX/SQRT(AIXX**2+AIYY**2))
      IF (AIYY .LT. 0.0) THIAP=-THIAP
      PHIAP=ASIN(AIZZ)
      DFB=SQRT(FBXX**2+FBYY**2+FBZZ**2)
      FBHX=-FBYY/DFB
      FBHY=FBXX/DFB
      FBVX=-FBHY*FBZZ
      FBVY=FBHX*FBZZ
      FBVZ=FBHY*FBXX-FBHX*FBYY
      COGBP=COS(GBP)
      SIGBP=SIN(GBP)
      BIXX=COGBP*FBHX+SIGBP*FBVX
      BIYY=COGBP*FBHY+SIGBP*FBVY
      BIZZ=SIGBP*FBVZ
      THIBP=ACOS(BIXX/SQRT(BIXX**2+BIYY**2))
      IF (BIYY .LT. 0.0) THIBP=-THIBP
      PHIBP=ASIN(BIZZ)
      WRITE(6,999) THAP,PHAP,THIAP,PHIAP,GAP,THBP,
     1PHBP,THIBP,PHIBP,GBP
  999 FORMAT(5H CORR,5E13.6/5X,5E13.6)
 1000 RETURN
      END
      SUBROUTINE ALL(NA,NB,TA,TB,NFRA,NFRB,XA,YA,XB,YB,SMEAN,
     1SSDEV,DT,XX,YY,ZZ,DESIG,NCHK)
      COMMON RAA,RAB,RAC,FA,THA,PHA,GA,RBA,RBB,RBC,FB,THB,PHB,
     1GB,THIA,PHIA,THIB,PHIB
      DIMENSION TA(150),TB(150),NFRA(150),NFRB(150),XA(150,8),YA(150,8),
     1XB(150,8),YB(150,8),SMEAN(8),SSDEV(8),XX(10),YY(10),ZZ(10)
```

```
      PB=P
      QB=Q
      NT=NT+1
      CALL SOLVE(PA,QA,PB,QB,NT,SOLA,SOLB,SOLC,D,J,NCHK,NTR)
      IF (J .NE. 5) GO TO 15
      NTESP=NTESP+1
      TIM(NTESP)=TS
   15 ID=J-4
      X(NTESP,ID)=SOLA*12.0
      Y(NTESP,ID)=-SOLB*12.0
      Z(NTESP,ID)=SOLC*12.0
      D=ABS(D)
      DD(NTESP,ID)=D*12.0
      SMEAN(J)=SMEAN(J)+D
      SSDEV(J)=SSDEV(J)+D**2
7     CONTINUE
      GO TO 1
1000  XN=NTESP
      DO 10 J=1,8
      ARGA=SMEAN(J)**2/XN
      SSDEV(J)=(SSDEV(J)-ARGA)/(XN-1.0)
      SSDEV(J)=SQRT(SSDEV(J))*12.0
      SMEAN(J)=SMEAN(J)*12.0/XN
      WRITE(6,11) NTESP,J,SMEAN(J),SSDEV(J)
11    FORMAT(25H NO OF PTS,PT NO,MEAN,DEV,2I5,2E13.6)
   10 CONTINUE
      DO 12 J=5,7,2
      K=J+1
      ID=J-4
      JD=J-3
      DO 12 I=1,NTESP
      DIS=SQRT((X(I,JD)-X(I,ID))**2+(Y(I,JD)-Y(I,ID))**2+(Z(I,JD)-
     1Z(I,ID))**2)
      WRITE(6,14)TIM(I),X(I,ID),Y(I,ID),Z(I,ID),X(I,JD),Y(I,JD),
     1Z(I,JD),DESIG,J,K,DIS,DD(I,ID),DD(I,JD)
      WRITE(7,13)TIM(I),X(I,ID),Y(I,ID),Z(I,ID),X(I,JD),Y(I,JD),
     1Z(I,JD),DESIG,J,K
   14 FORMAT(F5.3,6F6.2,5H RUN ,F5.0,5H PTS ,I2,5H AND ,I2,3E13.6)
   13 FORMAT(F5.3,6F6.2,5H RUN ,F5.0,5H PTS ,I2,5H AND ,I2)
   12 CONTINUE
      IF (NCHK .GT. 0) GO TO 1001
      NCHK=1
      GO TO 9
 1001 RETURN
      END
```

```
CAMERA DATA
-.346811E+01  .318643E+01  .377726E+01  .666667E+00 -.565559E+00 -.313279E+00  .413188E-01  .374504E+00  .392092E-01
CAMERA DATA
-.337545E+01 -.339973E+01  .363636E+01  .672540E+00  .642761E+00 -.239090E+00  .147729E-01  .221306E+01  .141190E-01
HARD PT LOCATIONS  .376917E+01  .143750E+01  .376633E+01
HARD PT LOCATIONS  .360167E+01  .325630E+00  .376333E+01
HARD PT LOCATIONS  .361000E+01 -.640330E+00  .376583E+01
HARD PT LOCATIONS  .550000E-01  .109333E+01  .406670E+00
HARD PT LOCATIONS  .733300E-01  .583330E+00  .643330E+00
HARD PT LOCATIONS  .733300E-01 -.551670E+00  .656670E+00
HARD PT LOCATIONS  .375000E-01 -.106250E+01  .507500E+00
HARD PT LOCATIONS  .758300E-01 0.             .676670E+00
HARD PT LOCATIONS  .750000E-02 0.             .291670E+00
REF TIMES&FRAME NOS  .141864E+00   80    2
REF TIMES&FRAME NOS  .208136E+00  112    2
REF TIMES&FRAME NOS  .140412E+00   80    2
REF TIMES&FRAME NOS  .196144E+00  109    2
   1    80  .141864E+00
 .153333E+00  .213583E+00  .611667E-01  .213750E+00 -.101083E+00 -.216667E+00 -.257417E+00 -.196667E+00
 .732500E-01  .139833E+00  .477500E-01  .127333E+00 -.153167E+00  .131750E+00 -.139000E+00  .635833E-01
   2    81  .143935E+00
 .153750E+00  .213167E+00  .619167E-01  .213417E+00 -.101000E+00 -.219083E+00 -.257750E+00 -.196167E+00
 .713333E-01  .136417E+00  .456667E-01  .125500E+00 -.155750E+00  .129500E+00 -.136917E+00  .805000E-01
   3    82  .146006E+00
 .153633E+00  .212417E+00  .623333E-01  .212917E+00 -.101250E+00 -.219000E+00 -.257583E+00 -.197667E+00
 .696667E-01  .134633E+00  .416667E-01  .124167E+00 -.157417E+00  .123667E+00 -.136500E+00  .767500E-01
   4    83  .148077E+00
 .153917E+00  .211917E+00  .625833E-01  .212417E+00 -.101500E+00 -.219250E+00 -.257833E+00 -.196083E+00
 .662500E-01  .132250E+00  .395833E-01  .122833E+00 -.156750E+00  .119667E+00 -.138250E+00  .746667E-01
   5    84  .150148E+00
 .153667E+00  .213167E+00  .619333E-01  .213583E+00 -.101500E+00 -.216083E+00 -.258500E+00 -.197667E+00
 .639167E-01  .132250E+00  .388333E-01  .121083E+00 -.160917E+00  .116750E+00 -.137000E+00  .738333E-01
   6    85  .152219E+00
 .153333E+00  .214417E+00  .613333E-01  .215083E+00 -.100917E+00 -.217583E+00 -.258167E+00 -.196583E+00
 .612500E-01  .128250E+00  .391667E-01  .117583E+00 -.162750E+00  .113250E+00 -.136500E+00  .719167E-01
   7    86  .154290E+00
 .152500E+00  .215833E+00  .606667E-01  .215833E+00 -.100583E+00 -.217750E+00 -.258167E+00 -.196583E+00
 .599167E-01  .124167E+00  .392500E-01  .113417E+00 -.164000E+00  .108917E+00 -.134500E+00  .698333E-01
   8    87  .156361E+00
 .151500E+00  .216583E+00  .595000E-01  .216583E+00 -.999167E-01 -.218167E+00 -.257250E+00 -.197583E+00
 .583333E-01  .117750E+00  .401667E-01  .106750E+00 -.165167E+00  .103917E+00 -.134633E+00  .657500E-01
   9    88  .158432E+00
 .150833E+00  .216917E+00  .597500E-01  .216500E+00 -.994167E-01 -.217333E+00 -.257167E+00 -.196083E+00
 .570000E-01  .112083E+00  .411667E-01  .977500E-01 -.164583E+00  .994167E-01 -.133833E+00  .640000E-01
  10    89  .160503E+00
 .150750E+00  .216583E+00  .590000E-01  .215833E+00 -.995833E-01 -.217667E+00 -.257500E+00 -.196500E+00
 .579167E-01  .105333E+00  .420000E-01  .898333E-01 -.164250E+00  .965000E-01 -.130917E+00  .625000E-01
  11    90  .162574E+00
 .151417E+00  .217083E+00  .598333E-01  .216750E+00 -.995833E-01 -.217667E+00 -.257500E+00 -.196833E+00
 .574167E-01  .990833E-01  .441667E-01  .804167E-01 -.163417E+00  .936667E-01 -.128917E+00  .623333E-01
  12    91  .164645E+00
 .151333E+00  .217250E+00  .598333E-01  .216833E+00 -.101750E+00 -.207083E+00 -.258167E+00 -.187000E+00
 .581667E-01  .100417E+00  .460833E-01  .784167E-01 -.162083E+00  .100667E+00 -.127333E+00  .705833E-01
  13    92  .166716E+00
 .152583E+00  .216167E+00  .612500E-01  .216167E+00 -.102000E+00 -.217250E+00 -.258333E+00 -.195917E+00
 .590000E-01  .830000E-01  .602500E-01  .572500E-01 -.161417E+00  .889167E-01 -.123667E+00  .604167E-01
  14    93  .168787E+00
 .152583E+00  .216000E+00  .605833E-01  .216000E+00 -.102333E+00 -.216917E+00 -.258333E+00 -.195500E+00
 .588333E-01  .752500E-01  .533333E-01  .444167E-01 -.159417E+00  .860833E-01 -.123083E+00  .601667E-01
  15    94  .170858E+00
 .152250E+00  .214250E+00  .605000E-01  .214250E+00 -.102583E+00 -.217333E+00 -.259000E+00 -.196583E+00
 .576667E-01  .675000E-01  .576667E-01  .314167E-01 -.159083E+00  .840833E-01 -.121167E+00  .582500E-01
  16    95  .172929E+00
 .151750E+00  .214833E+00  .602500E-01  .214833E+00 -.103167E+00 -.217333E+00 -.259083E+00 -.196833E+00
 .562500E-01  .613333E-01  .601667E-01  .229167E-01 -.159667E+00  .816667E-01 -.116667E+00  .576667E-01
  17    96  .175000E+00
```

.152083E+00	.215333E+00	.599167E-01	.215333E+00	-.102500E+00	-.217750E+00	-.258333E+00	-.197250E+00
.555667E-01	.565833E-01	.601667E-01	.145833E-01	-.159083E+00	.810833E-01	-.118000E+00	.569167E-01
18 97	.177071E+00						
.151333E+00	.216000E+00	.595833E-01	.215750E+00	-.101667E+00	-.217083E+00	-.257417E+00	-.198083E+00
.543333E-01	.509167E-01	.576833E-01	.500000E-02	-.158250E+00	.736667E-01	-.116083E+00	.564167E-01
19 98	.179142E+00						
.150667E+00	.216417E+00	.586667E-01	.216083E+00	-.100250E+00	-.216667E+00	-.257167E+00	-.197917E+00
.523333E-01	.469167E-01	.537500E-01	.100000E-02	-.157583E+00	.795833E-01	-.116583E+00	.568333E-01
20 99	.181213E+00						
.150750E+00	.216667E+00	.595000E-01	.216167E+00	-.100667E+00	-.216667E+00	-.257417E+00	-.197417E+00
.517500E-01	.420000E-01	.566667E-01	.400000E-02	-.157167E+00	.789167E-01	-.114333E+00	.553333E-01
21 100	.183284E+00						
.150667E+00	.216083E+00	.591667E-01	.215833E+00	-.101167E+00	-.217083E+00	-.256083E+00	-.197167E+00
.508333E-01	.381667E-01	.634167E-01	.208333E-02	-.156500E+00	.790000E-01	-.114167E+00	.564167E-01
22 101	.185355E+00						
.151833E+00	.214833E+00	.600833E-01	.215083E+00	-.101417E+00	-.217250E+00	-.256083E+00	-.197000E+00
.511667E-01	.340000E-01	.648333E-01	-.558333E-02	-.155167E+00	.765833E-01	-.112500E+00	.555000E-01
23 102	.187426E+00						
.152417E+00	.215667E+00	.605833E-01	.215667E+00	-.102417E+00	-.215500E+00	-.259583E+00	-.195667E+00
.509167E-01	.320833E-01	.583333E-01	-.950000E-02	-.155333E+00	.809167E-01	-.112833E+00	.557500E-01
24 103	.189497E+00						
.152083E+00	.216250E+00	.604167E-01	.216417E+00	-.102500E+00	-.215250E+00	-.259500E+00	-.195000E+00
.518333E-01	.316667E-01	.565000E-01	-.925000E-02	-.153667E+00	.815833E-01	-.113167E+00	.564167E-01
25 104	.191568E+00						
.152167E+00	.216333E+00	.605833E-01	.216333E+00	-.101917E+00	-.215167E+00	-.258917E+00	-.194667E+00
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26 105	.193639E+00						
.151917E+00	.215250E+00	.597500E-01	.215417E+00	-.102417E+00	-.216000E+00	-.258750E+00	-.195917E+00
.543333E-01	.264167E-01	.631667E-01	-.100833E-01	-.153250E+00	.814167E-01	-.112917E+00	.558333E-01
27 106	.195710E+00						
.151167E+00	.215250E+00	.598333E-01	.215250E+00	-.101833E+00	-.217083E+00	-.258667E+00	-.196500E+00
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28 107	.197781E+00						
.150750E+00	.215333E+00	.595000E-01	.214917E+00	-.101083E+00	-.217583E+00	-.258333E+00	-.197667E+00
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29 108	.199852E+00						
.150250E+00	.215417E+00	.584167E-01	.214833E+00	-.101250E+00	-.217583E+00	-.258667E+00	-.196500E+00
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30 109	.201923E+00						
.150167E+00	.215833E+00	.580833E-01	.215417E+00	-.101417E+00	-.217667E+00	-.258333E+00	-.198333E+00
.575667E-01	.244167E-01	.714167E-01	-.114167E-01	-.152583E+00	.869167E-01	-.113583E+00	.600000E-01
31 110	.203994E+00						
.150750E+00	.216083E+00	.585833E-01	.215833E+00	-.101500E+00	-.217667E+00	-.258333E+00	-.198167E+00
.593333E-01	.250000E-01	.765833E-01	-.975000E-02	-.150583E+00	.900833E-01	-.113417E+00	.600000E-01
32 111	.206065E+00						
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33 112	.208136E+00						
.151583E+00	.216000E+00	.599167E-01	.216500E+00	-.102333E+00	-.213083E+00	-.259000E+00	-.192333E+00
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1 80	.140412E+00						
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.880000E-01	.150833E+00	.111083E+00	.136333E+00	-.145250E+00	.108667E+00	-.138750E+00	.441667E-01
2 81	.142474E+00						
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.942500E-01	.146917E+00	.116083E+00	.133500E+00	-.141417E+00	.101667E+00	-.136417E+00	.386667E-01
3 82	.144536E+00						
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.991667E-01	.146917E+00	.119250E+00	.133083E+00	-.139500E+00	.969167E-01	-.134417E+00	.354167E-01
4 83	.146598E+00						
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.102417E+00	.145750E+00	.123250E+00	.132250E+00	-.137083E+00	.920833E-01	-.134000E+00	.325833E-01
5 84	.148660E+00						
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.103333E+00	.144667E+00	.120833E+00	.133500E+00	-.132667E+00	.860000E-01	-.131583E+00	.304167E-01
6 85	.150722E+00						

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.113417E+00	.142083E+00	.132500E+00	.132083E+00	-.130583E+00	.631667E-01	-.130917E+00	.270000E-01
7	86	.152784E+00					
-.387500E-01	.214583E+00	-.125583E+00	.216667E+00	-.226833E+00	.219083E+00	.233167E+00	-.203333E+00
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8	87	.154845E+00					
-.383333E-01	.214833E+00	-.124583E+00	.217083E+00	-.226167E+00	.220083E+00	.232500E+00	-.203583E+00
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9	88	.156907E+00					
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.125250E+00	.131500E+00	.145500E+00	.121750E+00	-.122917E+00	.683333E-01	-.132417E+00	.201667E-01
10	89	.158969E+00					
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.129333E+00	.127333E+00	.150250E+00	.116833E+00	-.120833E+00	.647500E-01	-.128250E+00	.207500E-01
11	90	.161031E+00					
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.134167E+00	.121917E+00	.155333E+00	.109500E+00	-.116667E+00	.613333E-01	-.129333E+00	.226333E-01
12	91	.163093E+00					
-.338333E-01	.219583E+00	-.120917E+00	.223083E+00	-.223667E+00	.227833E+00	.231167E+00	-.204000E+00
.134750E+00	.116833E+00	.157000E+00	.102583E+00	-.117750E+00	.582500E-01	-.128917E+00	.231667E-01
13	92	.165155E+00					
-.348333E-01	.220750E+00	-.121917E+00	.224083E+00	-.225083E+00	.228750E+00	.230250E+00	-.201917E+00
.137083E+00	.111833E+00	.159667E+00	.962500E-01	-.118000E+00	.553333E-01	-.130500E+00	.235833E-01
14	93	.167216E+00					
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.135417E+00	.106500E+00	.160667E+00	.884167E-01	-.119083E+00	.522500E-01	-.133417E+00	.236667E-01
15	94	.169278E+00					
-.359167E-01	.219833E+00	-.123000E+00	.222417E+00	-.226333E+00	.226000E+00	.232917E+00	-.200667E+00
.138333E+00	.101833E+00	.162417E+00	.791667E-01	-.118333E+00	.431667E-01	-.132750E+00	.233333E-01
16	95	.171340E+00					
-.379167E-01	.217250E+00	-.125000E+00	.219583E+00	-.228000E+00	.222167E+00	.233083E+00	-.200333E+00
.135500E+00	.945000E-01	.161333E+00	.682500E-01	-.119917E+00	.421667E-01	-.131667E+00	.316667E-01
17	96	.173402E+00					
-.377500E-01	.214917E+00	-.124000E+00	.217000E+00	-.227333E+00	.219000E+00	.234500E+00	-.202917E+00
.135000E+00	.873333E-01	.157917E+00	.614167E-01	-.119833E+00	.385000E-01	-.135333E+00	.263333E-01
18	97	.175464E+00					
-.380000E-01	.214583E+00	-.124083E+00	.216833E+00	-.227667E+00	.219083E+00	.234250E+00	-.203583E+00
.135417E+00	.821667E-01	.155167E+00	.540000E-01	-.121583E+00	.367500E-01	-.139417E+00	.267500E-01
19	98	.177526E+00					
-.385000E-01	.215917E+00	-.125000E+00	.216750E+00	-.227917E+00	.221417E+00	.231583E+00	-.203417E+00
.131583E+00	.778333E-01	.150083E+00	.488333E-01	-.123583E+00	.365000E-01	-.139500E+00	.315833E-01
20	99	.179588E+00					
-.378333E-01	.216833E+00	-.124500E+00	.219583E+00	-.227833E+00	.222750E+00	.231250E+00	-.203583E+00
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21	100	.181649E+00					
-.369167E-01	.218000E+00	-.123333E+00	.220917E+00	-.227083E+00	.224333E+00	.231917E+00	-.202833E+00
.129417E+00	.716667E-01	.147083E+00	.445000E-01	-.126750E+00	.371667E-01	-.138917E+00	.286667E-01
22	101	.183711E+00					
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.128500E+00	.672500E-01	.142500E+00	.446667E-01	-.126833E+00	.332500E-01	-.139083E+00	.301667E-01
23	102	.185773E+00					
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24	103	.187835E+00					
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.124250E+00	.642500E-01	.141000E+00	.410000E-01	-.131833E+00	.332500E-01	-.141417E+00	.330000E-01
25	104	.189897E+00					
-.357500E-01	.219750E+00	-.122250E+00	.222833E+00	-.225083E+00	.226750E+00	.231333E+00	-.201917E+00
.120917E+00	.614167E-01	.136083E+00	.374167E-01	-.131917E+00	.332500E-01	-.146583E+00	.308333E-01
26	105	.191959E+00					
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27	106	.194021E+00					
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28	107	.196082E+00					

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-.385833E-01  .217333E+00 -.125083E+00  .220083E+00 -.226250E+00  .223500E+00  .229917E+00 -.203417E+00
 .101417E+00  .550000E-01  .131000E+00  .480833E-01 -.156750E+00  .526667E-01 -.154250E+00  .159167E-01
TIME INCREMENT  .200000E-02
FIND  .141364E+00  .732500E-01  .139833E+00  .713333E-01  .138417E+00  .142000E+00
FIND  .140412E+00  .880000E-01  .150833E+00  .942500E-01  .146917E+00  .142000E+00
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FIND  .141364E+00  .477500E-01  .127333E+00  .456667E-01  .125500E+00  .142000E+00
FIND  .140412E+00  .111083E+00  .136333E+00  .116083E+00  .133500E+00  .142000E+00
SOLVE  .475130E-01  .127213E+00  .114933E+00  .134192E+00  .963998E+00  .838819E+00  .319169E+01   1
FIND  .141364E+00 -.153167E+00  .131750E+00 -.155750E+00  .128500E+00  .142000E+00
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SOLVE -.153336E+00  .131536E+00 -.142297E+00  .103273E+00  .658074E+00  .603670E+00  .311333E+01   2
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SOLVE -.133995E+00  .633806E-01 -.136953E+00  .399305E-01  .371136E+00 -.143914E+01  .294756E+01   3
CORR -.591467E+00 -.326242E+00  .975700E+00  .106679E-01  .112619E-01
      .645346E+00 -.294181E+00  .220658E+01  .301646E-01  .329565E-01
FIND  .143935E+00  .713333E-01  .138417E+00  .696667E-01  .134833E+00  .144000E+00
FIND  .142474E+00  .942500E-01  .146917E+00  .991667E-01  .146917E+00  .144000E+00
SOLVE  .712809E-01  .138304E+00  .978874E-01  .146917E+00  .971617E+00 -.137683E+01  .248570E+01   4
FIND  .143335E+00  .456667E-01  .125500E+00  .416667E-01  .124167E+00  .144000E+00
FIND  .142474E+00  .116083E+00  .133500E+00  .119250E+00  .133083E+00  .144000E+00
SOLVE  .455409E-01  .125458E+00  .113426E+00  .133192E+00  .913493E+00  .851242E+00  .316694E+01   5
FIND  .143335E+00 -.155750E+00  .126500E+00 -.157417E+00  .123667E+00  .144000E+00
FIND  .142474E+00 -.141417E+00  .101667E+00 -.139500E+00  .969167E-01  .144000E+00
SOLVE -.155802E+00  .126348E+00 -.139998E+00  .981503E-01  .622057E+00  .808621E+00  .310658E+01   6
FIND  .143935E+00 -.138917E+00  .605000E-01 -.138500E+00  .767500E-01  .144000E+00
FIND  .142474E+00 -.136417E+00  .366667E-01 -.134417E+00  .354167E-01  .144000E+00
SOLVE -.135904E+00  .803821E-01 -.134936E+00  .362611E-01  .839366E+00 -.143912E+01  .291911E+01   7
CORR -.591334E+00 -.326240E+00  .975660E+00  .112360E-01  .118617E-01
      .645192E+00 -.294222E+00  .220663E+01  .295352E-01  .322460E-01
FIND  .143335E+00  .713333E-01  .138417E+00  .696667E-01  .134833E+00  .146000E+00
FIND  .144536E+00  .991667E-01  .146917E+00  .102417E+00  .145750E+00  .146000E+00
SOLVE  .695714E-01  .134844E+00  .101474E+00  .146088E+00  .962115E+00 -.136707E+01  .245950E+01   8
FIND  .143335E+00  .456667E-01  .125500E+00  .416667E-01  .124167E+00  .146000E+00
FIND  .144536E+00  .119250E+00  .133083E+00  .123250E+00  .132250E+00  .146000E+00
SOLVE  .415731E-01  .124170E+00  .122089E+00  .132492E+00  .877114E+00  .859940E+00  .317399E+01   9
FIND  .143335E+00 -.155750E+00  .126500E+00 -.157417E+00  .123667E+00  .146000E+00
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SOLVE -.157412E+00  .123680E+00 -.137763E+00  .934834E-01  .576365E+00  .804796E+00  .310327E+01  10
FIND  .143335E+00 -.138917E+00  .605000E-01 -.138500E+00  .767500E-01  .146000E+00
FIND  .144536E+00 -.134417E+00  .354167E-01 -.134000E+00  .325833E-01  .146000E+00
SOLVE -.135501E+00  .767607E-01 -.134121E+00  .334048E-01  .815171E+00 -.143529E+01  .288486E+01  11
CORR -.591205E+00 -.325945E+00  .975715E+00  .114674E-01  .121047E-01
      .645203E+00 -.294588E+00  .220662E+01  .295713E-01  .322946E-01
FIND  .146006E+00  .696667E-01  .134833E+00  .662500E-01  .132250E+00  .148000E+00
FIND  .146598E+00  .102417E+00  .145750E+00  .108333E+00  .144667E+00  .148000E+00
SOLVE  .663768E-01  .132346E+00  .106439E+00  .145014E+00  .961762E+00 -.136113E+01  .243160E+01  12
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FIND	.146006E+00	.416667E-01	.124167E+00	.395833E-01	.122833E+00	.146000E+00		
FIND	.146598E+00	.123250E+00	.132250E+00	.126833E+00	.133500E+00	.148000E+00		
SOLVE	.396607E-01	.122863E+00	.127044E+00	.133100E+00				
FIND	.146006E+00	-.157417E+00	.123667E+00	-.155750E+00	.521051E+00	.364826E+00	.316504E+01	13
FIND	.146598E+00	-.137083E+00	.920833E-01	-.132667E+00	.119667E+00	.148000E+00		
SOLVE	-.155731E+00	.119815E+00	-.134076E+00	.693049E-01	.640000E-01	.146000E+00		
FIND	.146006E+00	-.138500E+00	.757500E-01	-.138250E+00	.531361E+00	.616240E+00	.310576E+01	14
FIND	.146598E+00	-.134000E+00	.325833E-01	-.131583E+00	.746667E-01	.148000E+00		
SOLVE	-.138259E+00	.747440E-01	-.132356E+00	.311036E-01	.304167E-01	.148000E+00		
CORR	-.591007E+00	-.325625E+00	.975635E+00	.121271E-01	.786762E+00	-.142266E+01	.265662E+01	15
	.645152E+00	-.294943E+00	.220667E+01	.292271E-01	.127998E-01			
FIND	.148077E+00	.662500E-01	.132250E+00	.633167E-01	.319255E-01			
FIND	.148560E+00	.108333E+00	.144667E+00	.113417E+00	.132250E+00	.150000E+00		
SOLVE	.640633E-01	.132250E+00	.111637E+00	.142968E+00	.142083E+00	.150000E+00		
FIND	.148077E+00	.395833E-01	.122833E+00	.308333E-01	.954734E+00	-.135151E+01	.241471E+01	16
FIND	.148560E+00	.128833E+00	.133500E+00	.132500E+00	.121083E+00	.150000E+00		
SOLVE	.385869E-01	.121208E+00	.131216E+00	.132579E+00	.132083E+00	.150000E+00		
FIND	.148077E+00	-.158750E+00	.119667E+00	-.160917E+00	.768332E+00	.674242E+00	.316066E+01	17
FIND	.148560E+00	-.132667E+00	.660000E-01	-.130583E+00	.116750E+00	.150000E+00		
SOLVE	-.160762E+00	.116958E+00	-.131312E+00	.646568E-01	.631667E-01	.150000E+00		
FIND	.148077E+00	-.138250E+00	.746667E-01	-.137000E+00	.497337E+00	.530756E+00	.310144E+01	18
FIND	.148560E+00	-.131583E+00	.304167E-01	-.130917E+00	.738333E-01	.150000E+00		
SOLVE	-.137089E+00	.736928E-01	-.131150E+00	.281955E-01	.270000E-01	.150000E+00		
CORR	-.590392E+00	-.325588E+00	.975671E+00	.125410E-01	.756587E+00	-.141849E+01	.283233E+01	19
	.645045E+00	-.295017E+00	.220671E+01	.287520E-01	.132364E-01			
FIND	.150148E+00	.639167E-01	.132250E+00	.612500E-01	.314073E-01			
FIND	.150722E+00	.113417E+00	.142083E+00	.117500E+00	.126250E+00	.152000E+00		
SOLVE	.615315E-01	.126672E+00	.115346E+00	.140533E+00	.139583E+00	.152000E+00		
FIND	.150148E+00	.388333E-01	.121083E+00	.391667E-01	.958637E+00	-.134250E+01	.239915E+01	20
FIND	.150722E+00	.132500E+00	.132083E+00	.136500E+00	.117583E+00	.152000E+00		
SOLVE	.391315E-01	.117353E+00	.134979E+00	.131464E+00	.131083E+00	.152000E+00		
FIND	.150148E+00	-.160917E+00	.116750E+00	-.162750E+00	.722355E+00	.600806E+00	.314175E+01	21
FIND	.150722E+00	-.130583E+00	.631667E-01	-.128083E+00	.113250E+00	.152000E+00		
SOLVE	-.162556E+00	.113620E+00	-.129032E+00	.600649E-01	.781667E-01	.152000E+00		
FIND	.150148E+00	-.137000E+00	.738333E-01	-.136500E+00	.472510E+00	.849643E+00	.308879E+01	22
FIND	.150722E+00	-.130917E+00	.270000E-01	-.130750E+00	.719167E-01	.152000E+00		
SOLVE	-.135553E+00	.721192E-01	-.130813E+00	.255532E-01	.246667E-01	.152000E+00		
CORR	-.590719E+00	-.325496E+00	.975600E+00	.132636E-01	.731019E+00	-.141574E+01	.260426E+01	23
	.644308E+00	-.295105E+00	.220676E+01	.260839E-01	.139986E-01			
FIND	.152219E+00	.612500E-01	.126250E+00	.599167E-01	.306797E-01			
FIND	.152784E+00	.117500E+00	.139583E+00	.121167E+00	.124167E+00	.154000E+00		
SOLVE	.601031E-01	.124736E+00	.119663E+00	.137371E+00	.135833E+00	.154000E+00		
FIND	.152219E+00	.391667E-01	.117583E+00	.392500E-01	.961657E+00	-.133966E+01	.238019E+01	24
FIND	.152784E+00	.136500E+00	.131083E+00	.142000E+00	.113417E+00	.154000E+00		
SOLVE	.392383E-01	.113999E+00	.139745E+00	.128232E+00	.126250E+00	.154000E+00		
FIND	.152219E+00	-.162750E+00	.113250E+00	-.164000E+00	.656795E+00	.890873E+00	.311809E+01	25
FIND	.152784E+00	-.128083E+00	.781667E-01	-.125083E+00	.108917E+00	.154000E+00		
SOLVE	-.163825E+00	.109523E+00	-.126312E+00	.752147E-01	.731667E-01	.154000E+00		
FIND	.152219E+00	-.136500E+00	.719167E-01	-.134500E+00	.438732E+00	.371932E+00	.306623E+01	26
FIND	.152784E+00	-.130750E+00	.246667E-01	-.130333E+00	.698333E-01	.154000E+00		
SOLVE	-.134780E+00	.701248E-01	-.130504E+00	.227961E-01	.215000E-01	.154000E+00		
CORR	-.590506E+00	-.325462E+00	.975582E+00	.136550E-01	.707764E+00	-.140839E+01	.277242E+01	27
	.644303E+00	-.295159E+00	.220681E+01	.276429E-01	.144116E-01			
FIND	.154290E+00	.599167E-01	.124167E+00	.588333E-01	.301990E-01			
FIND	.154845E+00	.121167E+00	.135833E+00	.125250E+00	.117750E+00	.156000E+00		
SOLVE	.590219E-01	.118667E+00	.123453E+00	.133406E+00	.131500E+00	.156000E+00		
FIND	.154290E+00	.392500E-01	.113417E+00	.401667E-01	.975729E+00	-.133169E+01	.235759E+01	28
FIND	.154345E+00	.142000E+00	.126250E+00	.145500E+00	.106750E+00	.156000E+00		
SOLVE	.400071E-01	.107910E+00	.143360E+00	.123730E+00	.121750E+00	.156000E+00		
FIND	.154290E+00	-.164000E+00	.103917E+00	-.165167E+00	.652706E+00	.304218E+00	.308451E+01	29
FIND	.154345E+00	-.125083E+00	.731667E-01	-.122917E+00	.103917E+00	.156000E+00		
SOLVE	-.164963E+00	.104738E+00	-.123869E+00	.704585E-01	.683333E-01	.156000E+00		
FIND	.154290E+00	-.134500E+00	.698333E-01	-.134833E+00	.411719E+00	.896406E+00	.303085E+01	30
FIND	.154345E+00	-.130333E+00	.215000E-01	-.132417E+00	.657500E-01	.156000E+00		
SOLVE	-.134775E+00	.664514E-01	-.131500E+00	.207535E-01	.201667E-01	.156000E+00		
CORR	-.590550E+00	-.325378E+00	.975669E+00	.135684E-01	.686038E+00	-.140147E+01	.273776E+01	31
					.143198E-01			

	.544766E+00	-.295319E+00	.220677E+01	.276360E-01	.302621E-01			
FIND	.156361E+00	.588333E-01	.117750E+00	.570000E-01	.112083E+00	.158000E+00		
FIND	.156907E+00	.125250E+00	.131500E+00	.129333E+00	.127333E+00	.158000E+00		
SOLVE	.573619E-01	.113264E+00	.127414E+00	.129292E+00	.981650E+00	-.133614E+01	.233089E+01	32
FIND	.156361E+00	.401667E-01	.106750E+00	.411667E-01	.977500E-01	.158000E+00		
FIND	.156907E+00	.145500E+00	.121750E+00	.150250E+00	.116833E+00	.158000E+00		
SOLVE	.409584E-01	.996243E-01	.148017E+00	.119144E+00	.614654E+00	.915131E+00	.305160E+01	33
FIND	.156361E+00	-.165167E+00	.103917E+00	-.164583E+00	.994167E-01	.158000E+00		
FIND	.156907E+00	-.122917E+00	.683333E-01	-.120833E+00	.647500E-01	.158000E+00		
SOLVE	-.164705E+00	.100354E+00	-.121812E+00	.664332E-01	.386708E+00	.922715E+00	.298774E+01	34
FIND	.156361E+00	-.134833E+00	.657500E-01	-.133833E+00	.640000E-01	.158000E+00		
FIND	.156907E+00	-.132417E+00	.201667E-01	-.128250E+00	.207500E-01	.158000E+00		
SOLVE	-.134042E+00	.643648E-01	-.130207E+00	.204760E-01	.679139E+00	-.139058E+01	.270516E+01	35
CORR	-.590487E+00	-.325219E+00	.975785E+00	.134163E-01	.141565E-01			
	.644303E+00	-.295561E+00	.220672E+01	.279001E-01	.304874E-01			
FIND	.158432E+00	.570000E-01	.112083E+00	.579167E-01	.105333E+00	.160000E+00		
FIND	.158969E+00	.129333E+00	.127333E+00	.134167E+00	.121917E+00	.160000E+00		
SOLVE	.575943E-01	.106971E+00	.131750E+00	.124625E+00	.981558E+00	-.132494E+01	.231966E+01	36
FIND	.158432E+00	.411667E-01	.977500E-01	.420000E-01	.698333E-01	.160000E+00		
FIND	.158969E+00	.150250E+00	.116833E+00	.155333E+00	.109500E+00	.160000E+00		
SOLVE	.417979E-01	.917537E-01	.152792E+00	.113166E+00	.563330E+00	.938067E+00	.301435E+01	37
FIND	.158432E+00	-.164583E+00	.994167E-01	-.164250E+00	.965000E-01	.160000E+00		
FIND	.158969E+00	-.120833E+00	.647500E-01	-.118667E+00	.613333E-01	.160000E+00		
SOLVE	-.164331E+00	.972080E-01	-.119749E+00	.630406E-01	.355543E+00	.950655E+00	.294129E+01	38
FIND	.158432E+00	-.133833E+00	.640000E-01	-.130917E+00	.625000E-01	.160000E+00		
FIND	.158969E+00	-.128250E+00	.207500E-01	-.129333E+00	.226333E-01	.160000E+00		
SOLVE	-.131624E+00	.626640E-01	-.128792E+00	.217915E-01	.672431E+00	-.137943E+01	.268038E+01	39
CORR	-.590463E+00	-.325080E+00	.975962E+00	.129716E-01	.136865E-01			
	.644349E+00	-.295813E+00	.220662E+01	.283120E-01	.309423E-01			
FIND	.160503E+00	.579167E-01	.105333E+00	.574167E-01	.990833E-01	.162000E+00		
FIND	.161031E+00	.134167E+00	.121917E+00	.134750E+00	.116833E+00	.162000E+00		
SOLVE	.575551E-01	.100614E+00	.134441E+00	.119526E+00	.995547E+00	-.130513E+01	.231460E+01	40
FIND	.160503E+00	.420000E-01	.698333E-01	.441667E-01	.604167E-01	.162000E+00		
FIND	.161031E+00	.155333E+00	.109500E+00	.157000E+00	.102583E+00	.162000E+00		
SOLVE	.435669E-01	.830235E-01	.156117E+00	.106247E+00	.561951E+00	.951659E+00	.297435E+01	41
FIND	.160503E+00	-.164250E+00	.965000E-01	-.163417E+00	.936667E-01	.162000E+00		
FIND	.161031E+00	-.118667E+00	.613333E-01	-.117750E+00	.582500E-01	.162000E+00		
SOLVE	-.163647E+00	.944514E-01	-.118236E+00	.598837E-01	.338335E+00	.977729E+00	.288643E+01	42
FIND	.160503E+00	-.130917E+00	.625000E-01	-.128917E+00	.623333E-01	.162000E+00		
FIND	.161031E+00	-.129333E+00	.226333E-01	-.126917E+00	.231667E-01	.162000E+00		
SOLVE	-.129471E+00	.623795E-01	-.129137E+00	.229900E-01	.670613E+00	-.136985E+01	.265737E+01	43
CORR	-.590463E+00	-.324962E+00	.976174E+00	.123437E-01	.130256E-01			
	.644301E+00	-.296037E+00	.220650E+01	.288226E-01	.315047E-01			
FIND	.162574E+00	.574167E-01	.990833E-01	.581667E-01	.100417E+00	.164000E+00		
FIND	.163093E+00	.134750E+00	.116833E+00	.137083E+00	.111833E+00	.164000E+00		
SOLVE	.579330E-01	.100001E+00	.135777E+00	.114633E+00	.101665E+01	-.129658E+01	.231266E+01	44
FIND	.162574E+00	.441667E-01	.604167E-01	.460833E-01	.784167E-01	.164000E+00		
FIND	.163093E+00	.157000E+00	.102583E+00	.159667E+00	.962500E-01	.164000E+00		
SOLVE	.454865E-01	.790395E-01	.158174E+00	.997960E-01	.552396E+00	.958197E+00	.295221E+01	45
FIND	.162574E+00	-.163417E+00	.936667E-01	-.162083E+00	.100667E+00	.164000E+00		
FIND	.163093E+00	-.117750E+00	.582500E-01	-.118000E+00	.553333E-01	.164000E+00		
SOLVE	-.162499E+00	.984852E-01	-.117860E+00	.569665E-01	.330501E+00	.996540E+00	.284789E+01	46
FIND	.162574E+00	-.128917E+00	.623333E-01	-.127333E+00	.705833E-01	.164000E+00		
FIND	.163093E+00	-.128917E+00	.231667E-01	-.130500E+00	.235833E-01	.164000E+00		
SOLVE	-.127827E+00	.680127E-01	-.129613E+00	.233500E-01	.678323E+00	-.136817E+01	.266462E+01	47
CORR	-.590493E+00	-.325218E+00	.976271E+00	.119595E-01	.126211E-01			
	.544309E+00	-.295860E+00	.220645E+01	.287073E-01	.313752E-01			
FIND	.164645E+00	.581667E-01	.100417E+00	.590000E-01	.630000E-01	.166000E+00		
FIND	.165155E+00	.137083E+00	.111833E+00	.135417E+00	.106500E+00	.166000E+00		
SOLVE	.587125E-01	.890080E-01	.136399E+00	.109645E+00	.103294E+01	-.129661E+01	.233845E+01	48
FIND	.164645E+00	.460833E-01	.784167E-01	.502500E-01	.572500E-01	.166000E+00		
FIND	.165155E+00	.159667E+00	.962500E-01	.160667E+00	.884167E-01	.166000E+00		
SOLVE	.488120E-01	.645548E-01	.160077E+00	.930361E-01	.551493E+00	.971983E+00	.289338E+01	49
FIND	.164645E+00	-.162083E+00	.100667E+00	-.161417E+00	.889167E-01	.166000E+00		
FIND	.165155E+00	-.118000E+00	.553333E-01	-.119083E+00	.522500E-01	.166000E+00		
SOLVE	-.161647E+00	.929721E-01	-.118444E+00	.540691E-01	.330144E+00	.103068E+01	.277174E+01	50

FIND	.164645E+00	-.127333E+00	.705333E-01	-.123667E+00	.604167E-01	.166000E+00		
FIND	.165155E+00	-.130500E+00	.235833E-01	-.133417E+00	.236667E-01	.166000E+00		
SOLVE	-.124932E+00	.639259E-01	-.131695E+00	.236175E-01	.687668E+00	-.136661E+01	.262798E+01	51
CORR	-.590429E+00	-.325159E+00	.976369E+00	.118586E-01	.125143E-01			
	.544773E+00	-.295952E+00	.220641E+01	.287209E-01	.313919E-01			
FIND	.166716E+00	.590000E-01	.830000E-01	.588333E-01	.752500E-01	.168000E+00		
FIND	.167216E+00	.135417E+00	.106500E+00	.138333E+00	.101833E+00	.168000E+00		
SOLVE	.583966E-01	.761925E-01	.136525E+00	.104726E+00	.107113E+01	-.129215E+01	.231196E+01	52
FIND	.166716E+00	.502500E-01	.572500E-01	.533333E-01	.444167E-01	.168000E+00		
FIND	.167216E+00	.160667E+00	.684167E-01	.162417E+00	.791667E-01	.168000E+00		
SOLVE	.521624E-01	.492901E-01	.161332E+00	.646994E-01	.551136E+00	.980912E+00	.263465E+01	53
FIND	.166716E+00	-.161417E+00	.689167E-01	-.159417E+00	.660833E-01	.168000E+00		
FIND	.167216E+00	-.119083E+00	.522500E-01	-.118333E+00	.481667E-01	.168000E+00		
SOLVE	-.160176E+00	.871592E-01	-.116798E+00	.506977E-01	.333712E+00	.106351E+01	.266575E+01	54
FIND	.166716E+00	-.123667E+00	.604167E-01	-.123083E+00	.601667E-01	.168000E+00		
FIND	.167216E+00	-.133417E+00	.236667E-01	-.132750E+00	.293333E-01	.168000E+00		
SOLVE	-.123305E+00	.602617E-01	-.133163E+00	.258138E-01	.701341E+00	-.136143E+01	.256747E+01	55
CORR	-.590313E+00	-.324676E+00	.976499E+00	.118264E-01	.124792E-01			
	.544300E+00	-.296265E+00	.220635E+01	.289580E-01	.316571E-01			
FIND	.168787E+00	.588333E-01	.752500E-01	.576667E-01	.675000E-01	.170000E+00		
FIND	.169278E+00	.138333E+00	.101833E+00	.136500E+00	.945000E-01	.170000E+00		
SOLVE	.581496E-01	.707061E-01	.137691E+00	.992633E-01	.109438E+01	-.128803E+01	.229782E+01	56
FIND	.168787E+00	.533333E-01	.444167E-01	.576667E-01	.314167E-01	.170000E+00		
FIND	.169278E+00	.162417E+00	.791667E-01	.161333E+00	.682500E-01	.170000E+00		
SOLVE	.559720E-01	.366006E-01	.162037E+00	.753408E-01	.538651E+00	.986288E+00	.278706E+01	57
FIND	.168787E+00	-.159417E+00	.660833E-01	-.159083E+00	.840833E-01	.170000E+00		
FIND	.169278E+00	-.118333E+00	.481667E-01	-.119917E+00	.421667E-01	.170000E+00		
SOLVE	-.159221E+00	.649117E-01	-.118888E+00	.460664E-01	.342542E+00	.109278E+01	.260123E+01	58
FIND	.168787E+00	-.123083E+00	.601667E-01	-.121167E+00	.582500E-01	.170000E+00		
FIND	.169278E+00	-.132750E+00	.293333E-01	-.131667E+00	.316667E-01	.170000E+00		
SOLVE	-.121960E+00	.590437E-01	-.132371E+00	.301501E-01	.709453E+00	-.136036E+01	.255962E+01	59
CORR	-.590214E+00	-.324603E+00	.976680E+00	.115977E-01	.122368E-01			
	.544344E+00	-.296585E+00	.220626E+01	.293514E-01	.320934E-01			
FIND	.170358E+00	.576667E-01	.675000E-01	.562500E-01	.613333E-01	.172000E+00		
FIND	.171340E+00	.136500E+00	.945000E-01	.135000E+00	.673333E-01	.172000E+00		
SOLVE	.569851E-01	.640979E-01	.136019E+00	.922039E-01	.110170E+01	-.127304E+01	.230721E+01	60
FIND	.170358E+00	.576667E-01	.314167E-01	.601667E-01	.229167E-01	.172000E+00		
FIND	.171340E+00	.161333E+00	.682500E-01	.157917E+00	.614167E-01	.172000E+00		
SOLVE	.590454E-01	.267291E-01	.160236E+00	.660603E-01	.543436E+00	.975965E+00	.273203E+01	61
FIND	.170358E+00	-.159083E+00	.840833E-01	-.159667E+00	.816667E-01	.172000E+00		
FIND	.171340E+00	-.119917E+00	.421667E-01	-.119833E+00	.385000E-01	.172000E+00		
SOLVE	-.159405E+00	.827506E-01	-.119890E+00	.409931E-01	.367765E+00	.110730E+01	.252154E+01	62
FIND	.170358E+00	-.121167E+00	.582500E-01	-.118667E+00	.576667E-01	.172000E+00		
FIND	.171340E+00	-.131667E+00	.316667E-01	-.135333E+00	.263333E-01	.172000E+00		
SOLVE	-.119788E+00	.579282E-01	-.132839E+00	.299608E-01	.712540E+00	-.136891E+01	.253127E+01	63
CORR	-.590138E+00	-.324423E+00	.976886E+00	.112161E-01	.118334E-01			
	.544870E+00	-.296620E+00	.220614E+01	.297626E-01	.325696E-01			
FIND	.172929E+00	.562500E-01	.613333E-01	.556667E-01	.565833E-01	.174000E+00		
FIND	.173402E+00	.135000E+00	.673333E-01	.135417E+00	.621667E-01	.174000E+00		
SOLVE	.559482E-01	.588761E-01	.135121E+00	.858341E-01	.112417E+01	-.126570E+01	.229667E+01	64
FIND	.172929E+00	.601667E-01	.229167E-01	.601667E-01	.145833E-01	.174000E+00		
FIND	.173402E+00	.157917E+00	.614167E-01	.155167E+00	.540000E-01	.174000E+00		
SOLVE	.601667E-01	.186064E-01	.157118E+00	.592631E-01	.544671E+00	.969379E+00	.268533E+01	65
FIND	.172929E+00	-.159667E+00	.816667E-01	-.159083E+00	.810833E-01	.174000E+00		
FIND	.173402E+00	-.119833E+00	.385000E-01	-.121583E+00	.367500E-01	.174000E+00		
SOLVE	-.159365E+00	.813650E-01	-.120341E+00	.379926E-01	.394530E+00	.110562E+01	.245751E+01	66
FIND	.172929E+00	-.118667E+00	.576667E-01	-.118000E+00	.569167E-01	.174000E+00		
FIND	.173402E+00	-.135333E+00	.263333E-01	-.139417E+00	.267500E-01	.174000E+00		
SOLVE	-.118322E+00	.572788E-01	-.136516E+00	.264541E-01	.714834E+00	-.137262E+01	.251387E+01	67
CORR	-.590065E+00	-.324313E+00	.977064E+00	.109087E-01	.115087E-01			
	.644364E+00	-.296965E+00	.220603E+01	.300833E-01	.329015E-01			
FIND	.175000E+00	.556667E-01	.565833E-01	.543333E-01	.509167E-01	.176000E+00		
FIND	.175464E+00	.135417E+00	.821667E-01	.131583E+00	.778333E-01	.176000E+00		
SOLVE	.550226E-01	.538460E-01	.134419E+00	.810385E-01	.115909E+01	-.128211E+01	.227276E+01	68
FIND	.175000E+00	.601667E-01	.145833E-01	.575833E-01	.500000E-02	.176000E+00		
FIND	.175464E+00	.155167E+00	.540000E-01	.150083E+00	.488333E-01	.176000E+00		

SOLVE	.569183E-01	.995464E-02	.153643E+00	.526545E-01	.544773E+00	.964135E+00	.264618E+01	69
FIND	.175000E+00	-.159083E+00	.810833E-01	-.160250E+00	.796667E-01	.176000E+00		
FIND	.175464E+00	-.121583E+00	.367500E-01	-.123583E+00	.365000E-01	.176000E+00		
SOLVE	-.153651E+00	.803931E-01	-.122103E+00	.366650E-01	.411693E+00	.109165E+01	.239299E+01	70
FIND	.175000E+00	-.118000E+00	.569167E-01	-.116083E+00	.564167E-01	.176000E+00		
FIND	.175464E+00	-.139417E+00	.267500E-01	-.139500E+00	.315833E-01	.176000E+00		
SOLVE	-.117074E+00	.566752E-01	-.139436E+00	.260064E-01	.728953E+00	-.137930E+01	.250226E+01	71
CORR	-.589993E+00	-.324191E+00	.977256E+00	.105580E-01	.111363E-01			
	.644367E+00	-.297124E+00	.220591E+01	.304451E-01	.333004E-01			
FIND	.177071E+00	.543333E-01	.509167E-01	.523333E-01	.469167E-01	.176000E+00		
FIND	.177526E+00	.131583E+00	.770333E-01	.130833E+00	.751667E-01	.178000E+00		
SOLVE	.534359E-01	.491217E-01	.131411E+00	.772197E-01	.116715E+01	-.129059E+01	.227019E+01	72
FIND	.177071E+00	.575833E-01	.500000E-02	.537500E-01	.100000E-02	.178000E+00		
FIND	.177526E+00	.150083E+00	.486333E-01	.147667E+00	.443333E-01	.178000E+00		
SOLVE	.555633E-01	.320521E-02	.149527E+00	.477974E-01	.559136E+00	.946213E+00	.260931E+01	73
FIND	.177071E+00	-.158250E+00	.796667E-01	-.157583E+00	.795833E-01	.178000E+00		
FIND	.177526E+00	-.123583E+00	.365000E-01	-.125750E+00	.370833E-01	.178000E+00		
SOLVE	-.157951E+00	.796293E-01	-.124081E+00	.366341E-01	.428951E+00	.106360E+01	.234194E+01	74
FIND	.177071E+00	-.116083E+00	.564167E-01	-.116583E+00	.568333E-01	.178000E+00		
FIND	.177526E+00	-.139500E+00	.315833E-01	-.139917E+00	.289167E-01	.178000E+00		
SOLVE	-.115308E+00	.566036E-01	-.139596E+00	.303700E-01	.744593E+00	-.138597E+01	.249568E+01	75
CORR	-.589310E+00	-.324022E+00	.977444E+00	.102506E-01	.108133E-01			
	.644865E+00	-.297324E+00	.220579E+01	.308440E-01	.337403E-01			
FIND	.179142E+00	.523333E-01	.469167E-01	.517500E-01	.420000E-01	.180000E+00		
FIND	.179588E+00	.130833E+00	.751667E-01	.129417E+00	.716667E-01	.180000E+00		
SOLVE	.520916E-01	.448791E-01	.130550E+00	.744661E-01	.119458E+01	-.128531E+01	.228005E+01	76
FIND	.179142E+00	.537500E-01	.100000E-02	.566667E-01	.400000E-02	.180000E+00		
FIND	.179588E+00	.147667E+00	.443333E-01	.147083E+00	.445000E-01	.180000E+00		
SOLVE	.549581E-01	.224258E-02	.147550E+00	.443667E-01	.558703E+00	.938422E+00	.258156E+01	77
FIND	.179142E+00	-.157583E+00	.795833E-01	-.157167E+00	.789167E-01	.180000E+00		
FIND	.179588E+00	-.125750E+00	.370833E-01	-.126750E+00	.371667E-01	.180000E+00		
SOLVE	-.157411E+00	.793071E-01	-.125950E+00	.371000E-01	.439220E+00	.104970E+01	.232012E+01	78
FIND	.179142E+00	-.116583E+00	.568333E-01	-.114333E+00	.553333E-01	.180000E+00		
FIND	.179588E+00	-.139917E+00	.289167E-01	-.138917E+00	.286667E-01	.180000E+00		
SOLVE	-.115651E+00	.562116E-01	-.139717E+00	.288667E-01	.758133E+00	-.139272E+01	.249337E+01	79
CORR	-.589938E+00	-.323891E+00	.977624E+00	.992901E-02	.104736E-01			
	.644594E+00	-.297487E+00	.220568E+01	.312165E-01	.341543E-01			
FIND	.181213E+00	.517500E-01	.420000E-01	.508333E-01	.381667E-01	.182000E+00		
FIND	.181549E+00	.129417E+00	.716667E-01	.128500E+00	.672500E-01	.182000E+00		
SOLVE	.514016E-01	.405429E-01	.129261E+00	.709153E-01	.120139E+01	-.128493E+01	.226840E+01	80
FIND	.181213E+00	.566667E-01	.400000E-02	.634167E-01	.208333E-02	.182000E+00		
FIND	.181549E+00	.147083E+00	.445000E-01	.142500E+00	.446667E-01	.182000E+00		
SOLVE	.592303E-01	.327207E-02	.146303E+00	.445264E-01	.564525E+00	.931963E+00	.254881E+01	81
FIND	.181213E+00	-.157167E+00	.789167E-01	-.156500E+00	.790000E-01	.182000E+00		
FIND	.181649E+00	-.126750E+00	.371667E-01	-.126833E+00	.382500E-01	.182000E+00		
SOLVE	-.155913E+00	.789483E-01	-.126764E+00	.373508E-01	.469002E+00	.106601E+01	.231655E+01	82
FIND	.181213E+00	-.114333E+00	.553333E-01	-.114167E+00	.564167E-01	.182000E+00		
FIND	.181649E+00	-.138917E+00	.286667E-01	-.139083E+00	.301667E-01	.182000E+00		
SOLVE	-.114270E+00	.557450E-01	-.138945E+00	.289215E-01	.766325E+00	-.139443E+01	.249112E+01	83
CORR	-.589779E+00	-.323776E+00	.977803E+00	.957870E-02	.101037E-01			
	.644906E+00	-.297634E+00	.220555E+01	.316320E-01	.346095E-01			
FIND	.183284E+00	.508333E-01	.381667E-01	.511667E-01	.340000E-01	.184000E+00		
FIND	.183711E+00	.128500E+00	.672500E-01	.124917E+00	.655833E-01	.184000E+00		
SOLVE	.509486E-01	.367259E-01	.127998E+00	.671566E-01	.121036E+01	-.127454E+01	.226471E+01	84
FIND	.183284E+00	.634167E-01	.208333E-02	.648333E-01	-.558333E-02	.184000E+00		
FIND	.183711E+00	.142500E+00	.446667E-01	.143750E+00	.397500E-01	.184000E+00		
SOLVE	.639064E-01	-.566757E-03	.142675E+00	.439763E-01	.571306E+00	.926170E+00	.251671E+01	85
FIND	.183284E+00	-.156500E+00	.790000E-01	-.155167E+00	.785833E-01	.184000E+00		
FIND	.183711E+00	-.126833E+00	.382500E-01	-.125667E+00	.371667E-01	.184000E+00		
SOLVE	-.155039E+00	.788559E-01	-.126670E+00	.389983E-01	.518845E+00	.108061E+01	.229143E+01	86
FIND	.183284E+00	-.114167E+00	.564167E-01	-.112500E+00	.555000E-01	.184000E+00		
FIND	.183711E+00	-.139083E+00	.301667E-01	-.138417E+00	.301667E-01	.184000E+00		
SOLVE	-.113590E+00	.560997E-01	-.138990E+00	.301667E-01	.773239E+00	-.138979E+01	.249213E+01	87
CORR	-.589707E+00	-.323632E+00	.977356E+00	.934204E-02	.985359E-02			
	.644919E+00	-.297792E+00	.220544E+01	.319574E-01	.350018E-01			
FIND	.185355E+00	.511667E-01	.340000E-01	.509167E-01	.320833E-01	.186000E+00		

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FIND   .185773E+00  .124917E+00  .666833E-01  .124250E+00  .642500E-01  .186000E+00
SOLVE  .510688E-01  .334030E-01  .124643E+00  .663266E-01  .121673E+01 -.127166E+01  .227016E+01   88
FIND   .185355E+00  .648333E-01 -.558333E-02  .583333E-01 -.950000E-02  .186000E+00
FIND   .185773E+00  .143750E+00  .397500E-01  .141000E+00  .410000E-01  .186000E+00
SOLVE  .625073E-01 -.680380E-02  .143447E+00  .398376E-01  .595732E+00  .917015E+00  .249579E+01   89
FIND   .185355E+00 -.155167E+00  .765833E-01 -.155333E+00  .609167E-01  .186000E+00
FIND   .185773E+00 -.125667E+00  .371667E-01 -.131833E+00  .392500E-01  .186000E+00
SOLVE -.155213E+00  .793096E-01 -.126344E+00  .373955E-01  .506729E+00  .108248E+01  .225241E+01   90
FIND   .185355E+00 -.112500E+00  .555000E-01 -.112833E+00  .557500E-01  .186000E+00
FIND   .185773E+00 -.138417E+00  .301667E-01 -.141417E+00  .330000E-01  .186000E+00
SOLVE -.112604E+00  .555779E-01 -.138746E+00  .304780E-01  .778503E+00 -.138563E+01  .249067E+01   91
CORR  -.589514E+00 -.323457E+00  .970044E+00  .936036E-02  .967236E-02
       .644922E+00 -.297956E+00  .220536E+01  .321605E-01  .351347E-01
FIND   .187426E+00  .509167E-01  .320333E-01  .518333E-01  .316667E-01  .188000E+00
FIND   .187335E+00  .124250E+00  .642500E-01  .120917E+00  .614167E-01  .188000E+00
SOLVE  .511707E-01  .319679E-01  .123983E+00  .640231E-01  .122450E+01 -.126485E+01  .226734E+01   92
FIND   .187426E+00  .583333E-01 -.950000E-02  .565000E-01 -.925000E-02  .188000E+00
FIND   .187335E+00  .141000E+00  .410000E-01  .136083E+00  .374167E-01  .186000E+00
SOLVE  .573251E-01 -.943070E-02  .140606E+00  .407129E-01  .602490E+00  .914019E+00  .247881E+01   93
FIND   .187426E+00 -.155333E+00  .809167E-01 -.153667E+00  .815833E-01  .188000E+00
FIND   .187335E+00 -.131833E+00  .392500E-01 -.131917E+00  .392500E-01  .188000E+00
SOLVE -.154671E+00  .811015E-01 -.131640E+00  .392500E-01  .503864E+00  .104896E+01  .224566E+01   94
FIND   .187426E+00 -.112833E+00  .557500E-01 -.113167E+00  .564167E-01  .188000E+00
FIND   .187335E+00 -.141417E+00  .330000E-01 -.146583E+00  .308333E-01  .188000E+00
SOLVE -.112926E+00  .559347E-01 -.141829E+00  .328263E-01  .808303E+00 -.141225E+01  .250053E+01   95
CORR  -.589513E+00 -.323243E+00  .978107E+00  .948166E-02  .999959E-02
       .644935E+00 -.298148E+00  .220535E+01  .322911E-01  .353419E-01
FIND   .189497E+00  .518333E-01  .316667E-01  .572500E-01  .212500E-01  .190000E+00
FIND   .189397E+00  .120917E+00  .614167E-01  .116750E+00  .590833E-01  .190000E+00
SOLVE  .531488E-01  .291369E-01  .120708E+00  .612998E-01  .123680E+01 -.128090E+01  .227542E+01   96
FIND   .189497E+00  .565000E-01 -.925000E-02  .560000E-01 -.120000E-01  .190000E+00
FIND   .189397E+00  .136083E+00  .374167E-01  .136833E+00  .431667E-01  .190000E+00
SOLVE  .563786E-01 -.991786E-02  .136121E+00  .377040E-01  .637388E+00  .912376E+00  .244923E+01   97
FIND   .189497E+00 -.153667E+00  .815333E-01 -.153750E+00  .800833E-01  .190000E+00
FIND   .189397E+00 -.131917E+00  .392500E-01 -.136167E+00  .421667E-01  .190000E+00
SOLVE -.153687E+00  .812190E-01 -.132129E+00  .393956E-01  .531110E+00  .102182E+01  .222243E+01   98
FIND   .189497E+00 -.113167E+00  .564167E-01 -.113583E+00  .567500E-01  .190000E+00
FIND   .189397E+00 -.146583E+00  .308333E-01 -.148917E+00  .299167E-01  .190000E+00
SOLVE -.113268E+00  .564976E-01 -.146700E+00  .307875E-01  .819820E+00 -.140904E+01  .249961E+01   99
CORR  -.589424E+00 -.323071E+00  .978163E+00  .958733E-02  .101104E-01
       .644936E+00 -.298295E+00  .220531E+01  .323951E-01  .354589E-01
FIND   .191568E+00  .572500E-01  .212500E-01  .543333E-01  .254167E-01  .192000E+00
FIND   .191959E+00  .116750E+00  .590833E-01  .113333E+00  .579167E-01  .192000E+00
SOLVE  .565416E-01  .223277E-01  .116682E+00  .590600E-01  .126451E+01 -.131121E+01  .226461E+01  100
FIND   .191568E+00  .560000E-01 -.120000E-01  .631667E-01 -.100833E-01  .192000E+00
FIND   .191959E+00  .136833E+00  .431667E-01  .136917E+00  .451667E-01  .192000E+00
SOLVE  .574937E-01 -.116005E-01  .136835E+00  .432067E-01  .686434E+00  .920634E+00  .240396E+01  101
FIND   .191568E+00 -.153750E+00  .800833E-01 -.153250E+00  .814167E-01  .192000E+00
FIND   .191959E+00 -.136167E+00  .421667E-01 -.139083E+00  .420833E-01  .192000E+00
SOLVE -.153646E+00  .803614E-01 -.136225E+00  .421650E-01  .530415E+00  .103688E+01  .224231E+01  102
FIND   .191568E+00 -.113583E+00  .567500E-01 -.112917E+00  .558333E-01  .192000E+00
FIND   .191959E+00 -.148917E+00  .299167E-01 -.149750E+00  .292500E-01  .192000E+00
SOLVE -.113444E+00  .565568E-01 -.148933E+00  .299033E-01  .840354E+00 -.142669E+01  .250172E+01  103
CORR  -.589293E+00 -.322776E+00  .978116E+00  .101274E-01  .106769E-01
       .644946E+00 -.298528E+00  .220534E+01  .322991E-01  .353588E-01
FIND   .193539E+00  .543333E-01  .264167E-01  .540000E-01  .234167E-01  .194000E+00
FIND   .191959E+00  .116750E+00  .590833E-01  .113333E+00  .579167E-01  .194000E+00
SOLVE  .542752E-01  .258937E-01  .113367E+00  .579263E-01  .127603E+01 -.132498E+01  .225920E+01  104
FIND   .193639E+00  .631667E-01 -.100833E-01  .645833E-01 -.112500E-01  .194000E+00
FIND   .191959E+00  .136833E+00  .431667E-01  .136917E+00  .451667E-01  .194000E+00
SOLVE  .634135E-01 -.102866E-01  .136916E+00  .451467E-01  .699867E+00  .889352E+00  .240857E+01  105
FIND   .193539E+00 -.153250E+00  .814167E-01 -.151917E+00  .833333E-01  .194000E+00
FIND   .191959E+00 -.136167E+00  .421667E-01 -.139083E+00  .420833E-01  .194000E+00
SOLVE -.153018E+00  .817507E-01 -.139054E+00  .420842E-01  .559314E+00  .106829E+01  .225090E+01  106
FIND   .193539E+00 -.112917E+00  .558333E-01 -.112500E+00  .542500E-01  .194000E+00
FIND   .191959E+00 -.148917E+00  .299167E-01 -.149750E+00  .292500E-01  .194000E+00
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SOLVE -.112644E+00  .555973E-01 -.149742E+00  .232567E-01  .559722E+00 -.144004E+01  .250461E+01  107
CORR -.569167E+00 -.322544E+00  .976104E+00  .104660E-01  .115625E-01
      .544955E+00 -.298711E+00  .220535E+01  .322622E-01  .353443E-01
FIND  .195710E+00  .540000E-01  .234167E-01  .533333E-01  .239167E-01  .196000E+00
FIND  .194021E+00  .113333E+00  .579167E-01  .111417E+00  .577500E-01  .196000E+00
SOLVE  .539767E-01  .234867E-01  .111493E+00  .577567E-01  .128675E+01 -.132664E+01  .224944E+01  108
FIND  .195710E+00  .545833E-01 -.112500E-01  .666667E-01 -.139167E-01  .196000E+00
FIND  .194021E+00  .136917E+00  .451667E-01  .137250E+00  .472500E-01  .196000E+00
SOLVE  .648749E-01 -.116232E-01  .137237E+00  .471666E-01  .712543E+00  .662573E+00  .239571E+01  109
FIND  .195710E+00 -.151917E+00  .633333E-01 -.152333E+00  .637500E-01  .196000E+00
FIND  .194021E+00 -.139083E+00  .420833E-01 -.142917E+00  .429167E-01  .196000E+00
SOLVE -.151975E+00  .633917E-01 -.142763E+00  .428833E-01  .563473E+00  .106041E+01  .225489E+01  110
FIND  .195710E+00 -.112500E+00  .542500E-01 -.112083E+00  .562500E-01  .196000E+00
FIND  .194021E+00 -.149750E+00  .292500E-01 -.150167E+00  .303333E-01  .196000E+00
SOLVE -.112442E+00  .545300E-01 -.150150E+00  .302900E-01  .867123E+00 -.145556E+01  .251050E+01  111
CORR -.569063E+00 -.322266E+00  .976044E+00  .110345E-01  .116334E-01
      .544365E+00 -.298922E+00  .220539E+01  .321552E-01  .352099E-01
FIND  .197761E+00  .538333E-01  .239167E-01  .557500E-01  .245833E-01  .198000E+00
FIND  .196082E+00  .111417E+00  .577500E-01  .109083E+00  .566333E-01  .198000E+00
SOLVE  .540359E-01  .239871E-01  .109247E+00  .568975E-01  .129268E+01 -.132524E+01  .224715E+01  112
FIND  .197761E+00  .666667E-01 -.139167E-01  .670000E-01 -.130000E-01  .198000E+00
FIND  .196082E+00  .137250E+00  .472500E-01  .138000E+00  .535000E-01  .198000E+00
SOLVE  .667019E-01 -.136198E-01  .137947E+00  .530621E-01  .730735E+00  .872332E+00  .238975E+01  113
FIND  .197761E+00 -.152333E+00  .637500E-01 -.152583E+00  .651667E-01  .198000E+00
FIND  .196082E+00 -.142917E+00  .429167E-01 -.144750E+00  .431667E-01  .198000E+00
SOLVE -.152366E+00  .636997E-01 -.144622E+00  .431492E-01  .565137E+00  .109959E+01  .227473E+01  114
FIND  .197761E+00 -.112083E+00  .562500E-01 -.113667E+00  .568333E-01  .198000E+00
FIND  .196082E+00 -.150167E+00  .303333E-01 -.150000E+00  .249167E-01  .198000E+00
SOLVE -.112251E+00  .563116E-01 -.150012E+00  .252957E-01  .892948E+00 -.146675E+01  .251282E+01  115
CORR -.588921E+00 -.321966E+00  .977642E+00  .123911E-01  .127461E-01
      .544945E+00 -.299118E+00  .220562E+01  .316505E-01  .346614E-01
FIND  .199352E+00  .557500E-01  .245833E-01  .576667E-01  .244167E-01  .200000E+00
FIND  .198144E+00  .109083E+00  .568333E-01  .106583E+00  .575000E-01  .200000E+00
SOLVE  .555669E-01  .245714E-01  .106333E+00  .574334E-01  .129501E+01 -.133028E+01  .223567E+01  116
FIND  .199352E+00  .670000E-01 -.130000E-01  .714167E-01 -.114167E-01  .200000E+00
FIND  .198144E+00  .138000E+00  .535000E-01  .133167E+00  .516333E-01  .200000E+00
SOLVE  .673153E-01 -.126870E-01  .133649E+00  .519998E-01  .759606E+00  .671879E+00  .238860E+01  117
FIND  .199352E+00 -.152583E+00  .651667E-01 -.152583E+00  .659167E-01  .200000E+00
FIND  .198144E+00 -.144750E+00  .431667E-01 -.147333E+00  .447500E-01  .200000E+00
SOLVE -.152563E+00  .652916E-01 -.147075E+00  .445915E-01  .602373E+00  .108407E+01  .226396E+01  118
FIND  .199352E+00 -.113667E+00  .568333E-01 -.113583E+00  .600000E-01  .200000E+00
FIND  .198144E+00 -.150000E+00  .249167E-01 -.149917E+00  .230000E-01  .200000E+00
SOLVE -.113661E+00  .570594E-01 -.149925E+00  .231916E-01  .903067E+00 -.147998E+01  .252284E+01  119
CORR -.588754E+00 -.321702E+00  .977641E+00  .131149E-01  .138241E-01
      .544918E+00 -.299281E+00  .220566E+01  .311272E-01  .340917E-01
FIND  .201923E+00  .576667E-01  .244167E-01  .593333E-01  .250000E-01  .202000E+00
FIND  .200206E+00  .106583E+00  .575000E-01  .104667E+00  .559167E-01  .202000E+00
SOLVE  .577286E-01  .244333E-01  .104916E+00  .561224E-01  .128120E+01 -.133836E+01  .223402E+01  120
FIND  .201923E+00  .714167E-01 -.114167E-01  .765833E-01 -.975000E-02  .202000E+00
FIND  .200206E+00  .133167E+00  .518333E-01  .130167E+00  .520000E-01  .202000E+00
SOLVE  .716654E-01 -.113548E-01  .130556E+00  .519763E-01  .735053E+00  .673049E+00  .237706E+01  121
FIND  .201923E+00 -.152583E+00  .659167E-01 -.150583E+00  .900833E-01  .202000E+00
FIND  .200206E+00 -.147333E+00  .447500E-01 -.150750E+00  .465000E-01  .202000E+00
SOLVE -.152509E+00  .670343E-01 -.150305E+00  .462723E-01  .649131E+00  .109286E+01  .225934E+01  122
FIND  .201923E+00 -.113583E+00  .600000E-01 -.113417E+00  .600000E-01  .202000E+00
FIND  .200206E+00 -.149917E+00  .230000E-01 -.149167E+00  .139167E-01  .202000E+00
SOLVE -.113577E+00  .600000E-01 -.149264E+00  .203174E-01  .919645E+00 -.149610E+01  .253432E+01  123
CORR -.588558E+00 -.321500E+00  .977424E+00  .141536E-01  .149180E-01
      .544972E+00 -.299382E+00  .220581E+01  .305175E-01  .334259E-01
FIND  .203994E+00  .593333E-01  .250000E-01  .610000E-01  .259167E-01  .204000E+00
FIND  .202268E+00  .104667E+00  .559167E-01  .104167E+00  .551667E-01  .204000E+00
SOLVE  .593381E-01  .250026E-01  .104247E+00  .552866E-01  .127601E+01 -.133983E+01  .223826E+01  124
FIND  .203994E+00  .765833E-01 -.975000E-02  .794167E-01 -.808333E-02  .204000E+00
FIND  .202268E+00  .130167E+00  .520000E-01  .126917E+00  .500000E-01  .204000E+00
SOLVE  .765914E-01 -.874524E-02  .127436E+00  .503197E-01  .799204E+00  .677736E+00  .237276E+01  125
FIND  .203994E+00 -.150583E+00  .900833E-01 -.151667E+00  .931667E-01  .204000E+00
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FIND  .202268E+00 -.150750E+00  .465000E-01 -.152333E+00  .500000E-01  .204000E+00
SOLVE -.150586E+00  .900921E-01 -.152060E+00  .494396E-01  .700617E+00  .110425E+01  .224636E+01  126
FIND  .203994E+00 -.113417E+00  .600000E-01 -.117750E+00  .612500E-01  .204000E+00
FIND  .202268E+00 -.149167E+00  .159167E-01 -.149750E+00  .195833E-01  .204000E+00
SOLVE -.113429E+00  .600036E-01 -.149657E+00  .196367E-01  .945409E+00 -.149721E+01  .255607E+01  127
CORR -.588556E+00 -.321360E+00  .977255E+00  .149717E-01  .157796E-01
      .644825E+00 -.299439E+00  .220592E+01  .300166E-01  .326785E-01
FIND  .203994E+00  .593333E-01  .250000E-01  .610000E-01  .259167E-01  .206000E+00
FIND  .204330E+00  .104167E+00  .551667E-01  .101667E+00  .552500E-01  .206000E+00
SOLVE  .603476E-01  .258879E-01  .102141E+00  .552342E-01  .128178E+01 -.134204E+01  .223482E+01  128
FIND  .203994E+00  .765833E-01 -.975000E-02  .794167E-01 -.608333E-02  .206000E+00
FIND  .204330E+00  .126917E+00  .500000E-01  .130667E+00  .430000E-01  .206000E+00
SOLVE  .793276E-01 -.613573E-02  .129954E+00  .491901E-01  .824996E+00  .676576E+00  .237075E+01  129
FIND  .203994E+00 -.150583E+00  .900833E-01 -.151667E+00  .931667E-01  .206000E+00
FIND  .204330E+00 -.152333E+00  .500000E-01 -.156250E+00  .528333E-01  .206000E+00
SOLVE -.151633E+00  .930697E-01 -.155505E+00  .522943E-01  .695149E+00  .112611E+01  .224945E+01  130
FIND  .203994E+00 -.113417E+00  .600000E-01 -.117750E+00  .612500E-01  .206000E+00
FIND  .204330E+00 -.149750E+00  .195833E-01 -.153667E+00  .159167E-01  .206000E+00
SOLVE -.117614E+00  .612107E-01 -.152922E+00  .166140E-01  .952893E+00 -.151842E+01  .257922E+01  131
CORR -.588473E+00 -.321274E+00  .977112E+00  .156571E-01  .165015E-01
      .644774E+00 -.299451E+00  .220601E+01  .295619E-01  .323806E-01
FIND  .206065E+00  .610000E-01  .259167E-01  .631667E-01  .295000E-01  .208000E+00
FIND  .206392E+00  .101667E+00  .552500E-01  .101417E+00  .550000E-01  .208000E+00
SOLVE  .630242E-01  .292644E-01  .101472E+00  .550550E-01  .126043E+01 -.138088E+01  .223321E+01  132
FIND  .206065E+00  .794167E-01 -.808333E-02  .813333E-01 -.341667E-02  .208000E+00
FIND  .206392E+00  .130667E+00  .490000E-01  .131000E+00  .480833E-01  .208000E+00
SOLVE  .812074E-01 -.372341E-02  .130927E+00  .482850E-01  .941703E+00  .881044E+00  .238001E+01  133
FIND  .206065E+00 -.151667E+00  .931667E-01 -.149417E+00  .981667E-01  .208000E+00
FIND  .206392E+00 -.156250E+00  .528333E-01 -.156750E+00  .526667E-01  .208000E+00
SOLVE -.149565E+00  .978380E-01 -.156640E+00  .527033E-01  .697825E+00  .113392E+01  .226163E+01  134
FIND  .206065E+00 -.117750E+00  .612500E-01 -.115667E+00  .633333E-01  .208000E+00
FIND  .206392E+00 -.153667E+00  .159167E-01 -.154250E+00  .159167E-01  .208000E+00
SOLVE -.115804E+00  .631965E-01 -.154122E+00  .159167E-01  .976798E+00 -.151894E+01  .259986E+01  135
CORR -.588416E+00 -.321290E+00  .976985E+00  .162101E-01  .170844E-01
      .644703E+00 -.299369E+00  .220610E+01  .290698E-01  .318613E-01
NO OF PTS,PT NO,MEAN,DEV    34    1 0.          0.
NO OF PTS,PT NO,MEAN,DEV    34    2 0.          0.
NO OF PTS,PT NO,MEAN,DEV    34    3 0.          0.
NO OF PTS,PT NO,MEAN,DEV    34    4 0.          0.
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NO OF PTS,PT NO,MEAN,DEV    34    6  .776817E+00  .395669E+00
NO OF PTS,PT NO,MEAN,DEV    34    7  .245523E+00  .142561E+00
NO OF PTS,PT NO,MEAN,DEV    34    8  .847961E+00  .670091E+00
.142 11.57-10.07 38.30  7.90 -9.64 37.36 RUN  680. PTS  5 AND  6  .381361E+01  .994790E+00  .123246E+01
.144 10.96-10.21 38.24  7.46 -9.70 37.26 RUN  680. PTS  5 AND  6  .366363E+01  .981252E+00  .118891E+01
.146 10.53-10.32 38.09  6.92 -9.66 37.24 RUN  680. PTS  5 AND  6  .376601E+01  .781985E+00  .114239E+01
.148  9.85-10.38 37.98  6.38 -9.79 37.27 RUN  680. PTS  5 AND  6  .359585E+01  .686943E+00  .998137E+00
.150  9.22-10.49 37.93  5.98 -9.97 37.22 RUN  680. PTS  5 AND  6  .336167E+01  .900878E+00  .940312E+00
.152  8.67-10.57 37.70  5.67-10.20 37.07 RUN  680. PTS  5 AND  6  .308748E+01  .859161E+00  .821924E+00
.154  8.24-10.69 37.42  5.26-10.46 36.79 RUN  680. PTS  5 AND  6  .304960E+01  .866799E+00  .863434E+00
.156  7.83-10.85 37.01  4.94-10.76 36.37 RUN  680. PTS  5 AND  6  .296415E+01  .801622E+00  .864760E+00
.158  7.38-10.98 36.62  4.64-11.07 35.85 RUN  680. PTS  5 AND  6  .284278E+01  .773129E+00  .706766E+00
.160  7.00-11.26 36.17  4.27-11.41 35.30 RUN  680. PTS  5 AND  6  .287456E+01  .770970E+00  .730944E+00
.162  6.74-11.42 35.69  4.06-11.73 34.64 RUN  680. PTS  5 AND  6  .290028E+01  .806413E+00  .781920E+00
.164  6.63-11.50 35.43  3.97-11.96 34.17 RUN  680. PTS  5 AND  6  .297612E+01  .124887E+01  .115226E+01
.166  6.62-11.66 34.72  3.96-12.37 33.26 RUN  680. PTS  5 AND  6  .311219E+01  .874235E+00  .753161E+00
.168  6.61-11.77 34.02  4.00-12.76 32.23 RUN  680. PTS  5 AND  6  .331528E+01  .492256E+00  .426464E+00
.170  6.46-11.84 33.44  4.11-13.11 31.21 RUN  680. PTS  5 AND  6  .348010E+01  .438404E+00  .464156E+00
.172  6.52-11.71 32.78  4.41-13.29 30.26 RUN  680. PTS  5 AND  6  .364792E+01  .570896E+00  .620872E+00
.174  6.54-11.63 32.22  4.73-13.27 29.49 RUN  680. PTS  5 AND  6  .365967E+01  .761358E+00  .624239E+00
.176  6.54-11.57 31.75  4.94-13.10 28.72 RUN  680. PTS  5 AND  6  .375794E+01  .809497E+00  .517122E+00
.178  6.71-11.35 31.31  5.15-12.76 28.10 RUN  680. PTS  5 AND  6  .383673E+01  .735467E+00  .323390E+00
.180  6.70-11.26 30.98  5.27-12.60 27.84 RUN  680. PTS  5 AND  6  .369901E+01  .627485E+00  .538444E+00
.182  6.77-11.16 30.59  5.63-12.79 27.82 RUN  680. PTS  5 AND  6  .339556E+01  .594619E+00  .660283E+00
.184  6.86-11.11 30.20  6.23-12.97 27.50 RUN  680. PTS  5 AND  6  .333760E+01  .629389E+00  .412102E+00
.186  7.15-11.00 29.95  6.08-12.99 27.03 RUN  680. PTS  5 AND  6  .368978E+01  .380945E+00  .315409E+00
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.188	7.23	-10.97	29.75	6.35	-12.59	26.95	RUN	680.	PTS	5	AND	6	.344261E+01	.481776E+00	.145865E+00
.190	7.65	-10.95	29.39	6.37	-12.26	26.67	RUN	680.	PTS	5	AND	6	.328002E+01	.435763E+00	.340335E-02
.192	8.24	-11.05	28.85	6.36	-12.44	26.91	RUN	680.	PTS	5	AND	6	.303543E+01	.127539E+00	.677021E+00
.194	8.40	-10.67	28.90	6.71	-12.82	27.01	RUN	680.	PTS	5	AND	6	.332190E+01	.450327E+00	.656933E+00
.196	8.55	-10.59	28.75	6.76	-12.96	27.06	RUN	680.	PTS	5	AND	6	.342116E+01	.218001E+00	.945658E+00
.198	8.77	-10.47	28.60	6.78	-13.20	27.30	RUN	680.	PTS	5	AND	6	.364565E+01	.309650E+00	.169526E+01
.200	9.12	-10.46	28.66	7.23	-13.01	27.17	RUN	680.	PTS	5	AND	6	.350560E+01	.291951E+00	.159796E+01
.202	9.42	-10.40	28.52	7.73	-13.11	27.11	RUN	680.	PTS	5	AND	6	.340759E+01	.414447E+00	.146400E+01
.204	9.59	-10.53	28.47	8.41	-13.25	26.96	RUN	680.	PTS	5	AND	6	.332097E+01	.568908E+00	.113580E+01
.206	9.90	-10.52	28.45	8.34	-13.51	26.99	RUN	680.	PTS	5	AND	6	.367608E+01	.642779E+00	.769882E+00
.208	10.10	-10.57	28.56	8.37	-13.61	27.14	RUN	680.	PTS	5	AND	6	.376926E+01	.387781E+00	.240065E+00
.142	10.45	17.27	35.37	11.66	16.52	29.33	RUN	680.	PTS	7	AND	8	.572092E+01	.161303E-01	.204593E+00
.144	10.07	17.27	35.03	11.55	16.40	29.51	RUN	680.	PTS	7	AND	8	.577375E+01	.359404E-01	.210333E+00
.146	9.78	17.22	34.62	11.54	16.33	29.18	RUN	680.	PTS	7	AND	8	.578530E+01	.968348E-01	.685972E-01
.148	9.44	17.07	34.28	11.46	16.22	28.98	RUN	680.	PTS	7	AND	8	.573736E+01	.163103E+00	.668392E-01
.150	9.08	17.02	33.99	11.50	16.11	28.79	RUN	680.	PTS	7	AND	8	.580794E+01	.118676E+00	.263601E+00
.152	8.77	16.99	33.65	11.54	16.08	28.56	RUN	680.	PTS	7	AND	8	.586423E+01	.998170E-01	.307635E+00
.154	8.49	16.90	33.27	11.71	15.98	28.29	RUN	680.	PTS	7	AND	8	.599691E+01	.144211E+00	.363699E+00
.156	8.24	16.82	32.85	11.76	16.03	27.97	RUN	680.	PTS	7	AND	8	.607986E+01	.263890E+00	.114781E+00
.158	8.15	16.69	32.46	11.76	15.90	27.84	RUN	680.	PTS	7	AND	8	.593175E+01	.309941E+00	.601882E-01
.160	8.07	16.55	32.16	11.95	15.66	27.73	RUN	680.	PTS	7	AND	8	.592415E+01	.425707E+00	.267262E+00
.162	8.05	16.44	31.89	12.20	15.56	27.75	RUN	680.	PTS	7	AND	8	.592511E+01	.438707E+00	.384764E+00
.164	8.14	16.42	31.98	12.40	15.56	28.06	RUN	680.	PTS	7	AND	8	.584520E+01	.246902E+00	.244323E+00
.166	8.25	16.40	31.54	12.85	15.51	27.74	RUN	680.	PTS	7	AND	8	.602749E+01	.100323E+00	.208793E+00
.168	8.42	16.34	31.05	13.13	15.46	27.57	RUN	680.	PTS	7	AND	8	.592477E+01	.429629E+00	.605945E+00
.170	8.51	16.32	30.72	13.22	15.28	27.63	RUN	680.	PTS	7	AND	8	.569447E+01	.281415E+00	.126400E+01
.172	8.55	16.43	30.38	13.49	15.19	27.56	RUN	680.	PTS	7	AND	8	.581676E+01	.120417E+00	.135881E+01
.174	8.58	16.47	30.17	13.91	15.39	27.27	RUN	680.	PTS	7	AND	8	.616159E+01	.320275E-01	.115497E+01
.176	8.75	16.55	30.03	14.25	15.49	27.24	RUN	680.	PTS	7	AND	8	.625463E+01	.406714E-01	.138619E+01
.178	8.94	16.63	29.95	14.33	15.42	27.36	RUN	680.	PTS	7	AND	8	.610846E+01	.132471E+00	.164546E+01
.180	9.10	16.71	29.92	14.42	15.42	27.22	RUN	680.	PTS	7	AND	8	.610834E+01	.220391E+00	.149237E+01
.182	9.20	16.73	29.89	14.52	15.29	27.18	RUN	680.	PTS	7	AND	8	.615170E+01	.281378E+00	.151029E+01
.184	9.28	16.68	29.91	14.60	15.25	27.24	RUN	680.	PTS	7	AND	8	.611935E+01	.334220E+00	.156790E+01
.186	9.34	16.63	29.89	14.69	15.18	27.21	RUN	680.	PTS	7	AND	8	.616000E+01	.207071E+00	.163233E+01
.188	9.70	16.95	30.01	14.87	15.37	27.31	RUN	680.	PTS	7	AND	8	.603886E+01	.231483E+00	.186095E+01
.190	9.84	16.91	30.00	15.17	15.73	27.18	RUN	680.	PTS	7	AND	8	.614761E+01	.211664E+00	.170331E+01
.192	10.08	17.12	30.02	15.31	15.90	27.11	RUN	680.	PTS	7	AND	8	.610784E+01	.588218E+00	.165971E+01
.194	10.32	17.28	30.06	15.44	15.92	26.99	RUN	680.	PTS	7	AND	8	.612259E+01	.455129E+00	.171986E+01
.196	10.65	17.47	30.13	15.51	15.90	26.97	RUN	680.	PTS	7	AND	8	.600948E+01	.369540E+00	.193240E+01
.198	10.72	17.60	30.15	15.54	15.96	26.83	RUN	680.	PTS	7	AND	8	.608314E+01	.367135E+00	.126741E+01
.200	10.84	17.76	30.27	15.37	16.06	26.81	RUN	680.	PTS	7	AND	8	.595736E+01	.367744E+00	.101830E+01
.202	11.04	17.95	30.41	15.34	16.08	26.86	RUN	680.	PTS	7	AND	8	.588492E+01	.352673E+00	.402911E+00
.204	11.34	17.97	30.67	15.38	16.10	26.82	RUN	680.	PTS	7	AND	8	.588405E+01	.259094E+00	.344348E+00
.206	11.43	18.22	30.95	15.13	16.57	26.80	RUN	680.	PTS	7	AND	8	.579514E+01	.222877E+00	.765342E-01
.208	11.72	18.23	31.20	15.41	16.59	26.83	RUN	680.	PTS	7	AND	8	.594865E+01	.302142E+00	.236245E+00

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ERRATA STATEMENT

AMRL-TR-78-94, "Photometric Methods for the Analysis of Human Kinematic Responses to Impact Environments", October 1978 is revised as follows:

1. Page 11 - First complete paragraph, sixth and seventh sentences,

"The resultant displacement . . . and in G's.",

is changed to read,

A moving eleven point quadratic least square fit is then applied to these smoothed x and z-axis displacement data to obtain the x and z components of velocity. Next this same smoothing routine is applied to these x and z-axis velocity data to compute the x and z components of acceleration. The resultant displacement, velocity, and acceleration data are then computed using these smoothed x and z component data.

2. Page 15 - The equation used to calculate resultant displacement is changed to read:

$$RES(I) = \sqrt{XD(I)^2 + ZD(I)^2}$$

The second sentence following this equation, "Subroutine DERIV1 . . . in each case.", is changed to read,

Next subroutine DERIV1 is called to compute the X and Z components of velocity from the X and Z displacement data and then to compute the X and Z components of acceleration from the X and Z velocity data. In each case an eleven point quadratic smoothing

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AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

function is applied to the input displacement or velocity data. The velocity components are stored in arrays VX(I) and VZ(I) and the acceleration components in arrays AX(I) and AZ(I). The resultant velocity and acceleration data are computed as follows:

$$VEL(I) = \sqrt{VX(I)^2 + VZ(I)^2}$$

$$ACC(I) = \sqrt{AX(I)^2 + AZ(I)^2}$$

3. Appendix C - as follows:

Page 130 ---

Insert line 125:

2, VX(302), VZ(302), AX(302), AZ(302)

Insert line 185:

2, (XX(1,1), VX(1)), (XX(1,2), AX(1)), (ZZ(1,1), VZ(1)), (ZZ(1,2), AZ(1))

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Change Line 4480 to:

CALL DERIV1 (T, XD, VX, N, NP, 1)

Change Line 4500 to:

CALL DERIV1 (T, VX, AX, N, NP, 2)

Insert Line 4485:

CALL DERIV1 (T, ZD, VZ, N, NP, 1)

Insert Line 4505:

CALL DERIV1 (T, VZ, AZ, N, NP, 2)

Insert Line 4525:

VEL(I) = SQRT(VX(I) * VX(I) + VZ(I) *VZ(I))

Insert Line 4527:

ACC(I) = SQRT(AX(I) * AX(I) + AZ(I) * AZ(I))

4. Appendix D - Disregard tabular listings and plots of Resultant Velocity and Resultant Accelerations.

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